DOCUMENT RESUME

ED 363 613 SP 034 851

AUTHOR Salmi, Hannu
TITLE Science Centre Education. Motivation and Learning in Informal Education. Research Report 119.
INSTITUTION Helsinki Univ., (Finland). Dept. of Teacher Education.
REPORT NO ISBN-951-45-6475-8; ISSN-0359-4203
PUB DATE 93
NOTE 234p.; Academic Dissertation, University of Helsinki, Finland.
AVAILABLE FROM Department of Techer Education, P.O. Box 38 (Ratakatu 6A) 00014 University of Helsinki, Helsinki, Finland.
PUB TYPE Dissertations/Theses - Doctoral Dissertations (041)

EDRS PRICE MF01/PC10 Plus Postage.
DESCRIPTORS Cognitive Measurement; Exhibits; *Experiential Learning; Foreign Countries; Grade 7; Junior High Schools; *Learning Strategies; Museums; *Science Education; *Science Teaching Centers; Self Motivation; Situational Tests; *Student Motivation
IDENTIFIERS Finland (Helsinki); *Informal Education; Instrumental Learning Theory

ABSTRACT

This study investigates student learning in science center exhibitions as a form of informal education and examines intrinsic, instrumental, and situational student motivation. Subjects (N=130) consisted of 6 comprehensive school classes of 7th graders in the greater Helsinki area. The design of the study was quasi-experimental with two pre-treatment groups (intrinsic vs. instrumental motivation) and a situational motivation group as the control. Classes were tested by an intrinsic/instrumental motivation test, and by a specific situation motivation test measuring the exhibition experience. A knowledge test measured the effects of a pre-lesson and the learning of isolated facts and entities. Results indicated: (1) the intrinsic treatment group did best in nearly all cognitive tests; (2) the situation motivation group performed better than expected; (3) instrumental motivation does not apply to informal learning; (4) the theory of intrinsic, instrumental, and situation motivation, at least in informal education, is confirmed; (5) the science center exhibition proved to be a motivating setting for learning; and (6) it would be instructive to apply these findings to formal education. Appendixes provide Finnish and English versions of the testing instruments. (Contains approximately 360 references.) (LL)

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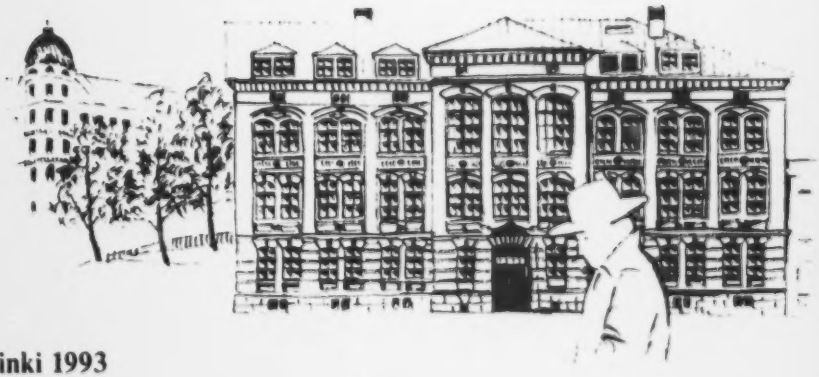
Motivation and Learning in Informal Education



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RESEARCH REPORT 119

Department of Teacher Education
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Hannu Salmi

SCIENCE CENTRE EDUCATION

Motivation and Learning in Informal Education

Academic dissertation

to be publicly discussed, by due permission of the Faculty of Education in the University of Helsinki, in Auditorium 1 of the Department of Teacher Education, on September 17th, 1993, at 12 o'clock.

Helsinki 1993

ISBN 951-45-6475-8
ISSN 0359-4203
Helsinki 1993
Yliopistopaino

UNIVERSITY OF HELSINKI, FINLAND
Faculty of Education Department of Teacher Education

Salmi, Hannu Sakari

Science Centre Education:
Motivation and Learning in Informal Education
202 + 10 pp.

ABSTRACT

The purpose of this study was to investigate learning in a science exhibition in order to further develop the theory of science centre education as a form of informal education. In studying motivation Engeström's model (1984) was used. This model separates intrinsic, instrumental and situation motivation.

The subjects (N:130) of this study consisted of six comprehensive school classes of 7th graders in the greater Helsinki area. The design of the study was quasi-experimental with two different pre-treatment groups (intrinsic vs. instrumental motivation). The situation motivation group was the control group.

The classes were tested by a common intrinsic/instumental motivation test, and by a specific situation motivation test measuring the exhibition experience. The knowledge test measured the effects of a pre-lesson, the learning of isolated facts and the learning of entities.

Common motivation tests were administrated three times and others twice: the pre-test three months before (T_0), the post-test three days after (T_1), and the delayed post-test six months after (T_2) the exhibition visit. The groups were homogeneous in terms of intrinsic and instrumental motivation before the treatments.

The intrinsic treatment group was the most positively motivated towards the exhibition. The difference from other groups was statistically significant (.05) and long-lasting.

The results showed that the intrinsic treatment group did best in nearly all cognitive tests. In particular, the group's ability to learn entities suggests a deep learning strategy. The situation motivation group performed better than expected. These results indicate that instrumental motivation does not apply to informal learning.

Finally, the results confirm the theory of intrinsic, instrumental and situation motivation at least in informal education. The science centre exhibition turned out to be a motivating setting for learning. It would be instructive to apply the results to formal education.

Keywords: science centre education; formal – informal education;
motivation, intrinsic - instrumental - situation motivation; learning strategies

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ACKNOWLEDGEMENTS

What is the most important thing you have ever learned? People give many answers to this question, most of which share one common feature: valuable things towards which you are strongly motivated have very often been learned outside school. This basic phenomenon led my interest and this study to the field of informal education.

Combining two wide subjects - motivation and informal/formal learning - was not an easy task. My supervisors from the Faculty of Education, University of Helsinki, were able to clarify the context of my work. Professor *Pertti Kansanen*'s seminar sessions in the Department of Teacher Education crystallised the aim of the study by comments on its design. I would also like to thank especially Assistant Professor *Juhani Hytönen* for his broad perspective and advice both on the theoretical background and practical methodology of the study. Comments and suggestions from Assistant Professor *Erkki Komulainen* made the final study much more comprehensive. The theoretical background to science centre education was extended by insightful tutorial help from Professor *Jarkko Hautamäki*, Department of Special Education. The clear ideas of Dr. *Patrick Scheinin*, University of Helsinki, were of great assistance in the statistical analysis of the data.

The innovative and stimulating process of planning the Heureka Science Centre gave me the opportunity to make an empirical test of motivation in informal education. I would like to thank Heureka's directors Dr. *Per-Edvin Persson* and Dr. *Hannu I. Miettinen* for encouraging me in this research work despite the

very practical demands of creating a new science centre. I have also been fortunate to get most valuable criticism of both the topic of science popularisation and the language of this study from Dr. *Melanie Quin*, Amsterdam Science Centre, an expert in both these fields.

Short but intensive discussions with Dr. *John Falk*, and Professor *Arthur Lucas*, King's College, London, focussed the aim of the study. Comments on the first outline of this study by Professor *Richard Gregory*, University of Bristol, helped me to find the basic elements of the topic. Professor *Yrjö Engeström*, University of Helsinki and University of San Diego, gave important support at the beginning of the study.

Thanks are also due to the Cultural Foundation of Finland for economic support for my pre-study, and to the Department of Teacher Education for accepting this study in their series of Research Reports.

Most of all I want to thank my dearest *Leena* for her loving throughout the study.

Helsinki, June 10th, 1993.

Hannu Salmi

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1. FORMAL AND INFORMAL EDUCATION

Learning and education can be defined both narrowly and a broadly: they can take place either unconsciously or formally. One of the first to define the broader meaning was the German philosopher Krieck, who used the term "unreflektierte Erziehung" - "education by chance". According to him, people also learn unconsciously through work, art, language and culture. The whole relationship between human beings is an educational one (Krieck 1922).

After the first World War, the term "education" began to be used in English to include the teaching of adults, as well as the teaching of children. The same change in terminology occurred in other languages as well, and it underlines the similarity of the process called "education" regardless of age. Especially the term "lifelong education", established during the 1980s, is strongly related to this approach (Harva 1981).

Learning and education are often used as synonyms. However, learning can occur with a learner alone - for education, a teacher and a learner are needed. Sometimes, learning without a tutor is called self-education, but even then some kind of material learning source and help are required.

Education is always a part of the socialisation process related to the psychological development of the individual and the values of the surrounding society. For centuries, especially in agricultural societies, education occurred inside the family: children learned skills taught by their parents (Heikkinen 1982). The apprenticeship institution came into being in

craftsman societies, where more complex skills were needed (Gardner 1991).

School is a phenomenon now taken for granted as the form of compulsory education, although the institution is only 150 years old. This specialised educational system is a necessity for modern society (Antikainen 1982). Formal education has also expanded to early childhood education (cf. Elkind 1986; Gardner 1991).

Education, upbringing, schooling, teaching and learning have been thoroughly discussed in the Finnish research literature (Hollo 1949, Harva 1963, Koskenniemi 1968, Viljanen 1973, Peltonen 1981, Engeström 1984). The use of the terms has been loose, and earlier the purpose of using educational terminology was to show the links between the different features (Suonperä 1979). In Finnish, there has been a discrepancy between the terms 'kasvatus' (= 1. education; 2. upbringing) and 'koulutus' (1. education; 2. schooling). In this study, the established definition of education ('kasvatus') is used as an inclusive-concept, including teaching ('opetus') as a tool for the process (cf. Renko & Piippo 1974).

The field of education is often divided into formal and informal education. The topic for most of the research in educational science has been formal education. This is very natural, because teaching and learning have traditionally occurred inside the school system. Society has wanted to know how the educational system can be improved. Thus educational research has taken place in a very close relationship to the values of society.

1.1. Informal education: background

Philosophically, informal education represents ideas of freedom in the spirit of Rousseau's tradition (Nurmi 1983; Bowen & Hobson 1988) and manifested, for example, in the work of Neill (1962; 1967). What is the meeting ground for the formal and informal?

Criticism against formal education has recently come from two different sources. First, in the 1960s, the radical pedagogues criticised the values maintained by the school system and their useless and ineffective teaching (Illich 1971a; Freire 1970). Second, in the 1980s, many leading figures of industry worried about recruiting enough well-educated people to work in high-tech jobs. School was, in their opinion, 10 years late in using computers (The National Science Board Commission 1983; CRAC 1986; EVA 1988).

Both the radical pedagogues and the top-industrialists - paradoxically - sought solutions to their problems in the same direction. They found that learning from informal sources and in out-of-school environments was effective and motivating.

One of the leading theorists of informal education, as mentioned above, is Ivan Illich. The Alternative to Schooling from 1971 contains harsh criticism of the failures of schooling, which have alienated people from genuine, socially responsible learning. Deschooling society, Illich's main thesis from 1971, makes this criticism in a more structured manner. The basic needs and the existence of informal education sources are described as follows (Illich 1971a, 109-110):

Such criticism leads many people to ask whether it is possible to conceive of a different style of learning. The same people, paradoxically, when pressed to specify how they acquire what they know and value, will readily admit that they have learned more often outside than inside school. Their knowledge of facts, their understanding of life and work came to them from friendship or love, while viewing TV, or while reading, from examples of peers or the challenge of a street encounter. Or they may have learned what they know through the apprenticeship ritual for admission to a street gang or the initiation to a hospital, newspaper city room, plumber's shop, or insurance office. The alternative to dependence on schools is not the use of public resources for some new device which 'makes' people learn; rather than it is the creation of a new style of educational relationship between man and his environment. To foster this style, attitudes toward growing up, the tools available for learning, and the quality and structure of daily life will have to change currently. Attitudes are already changing. The proud dependence on school is gone. (Illich 1971a, 109 -110).

In addition to his sharp criticism of schooling, Illich also creates new solutions for learning. The deschooling reform should happen in three steps: "The reformation of the classroom within the school system; the dispersal of free schools throughout the society; and the transformation of all society into one huge classroom (Illich 1971b)." Furthermore, the positive ideas for learning are the "Learning Webs", which consist of four kinds of nets: (1) Reference Services to Educational Objects; (2) Skill Exchanges; (3) Peer-Matching; and (4) Reference Services to Educator-at-Large (Illich 1971a, 117-154).

On the one hand Illich's classical study, Deschooling society, has been judged an unreachable ideal (e.g. Hirsjärvi & Remes 1987): on the other, informal education has been used as a tool for criticising school or school reforms; cf. the recent discussion concerning The National Curriculum in Great-Britain.

Perhaps the best known informal education projects have been carried out in the developing countries as reading and health campaigns. These projects have had a strongly ideological and motivational aspect (cf. Freire 1970; Bishop 1989; Takala 1989) and the main efforts have been in adult-education (see Torres 1990).

There has been very little research concerning informal education (Falk 1982, Bitgood 1988). More research is needed, particularly because some results indicate enormous effects on learning from informal sources (Maarschalk 1986; Bishop 1989).

Some researchers hold the strong opinion that informal education should not be studied using only classical quantitative methods (Diamond 1982; Bonner 1989). The latest trends in educational science support this position (Erickson 1986). But at the moment any research (either qualitative or quantitative) into informal education must be done very carefully, because the field is already well filled with imprecise data and results based on anecdotes or every-day-experiences (Balling & Falk 1981; Falk & Dierking 1992).

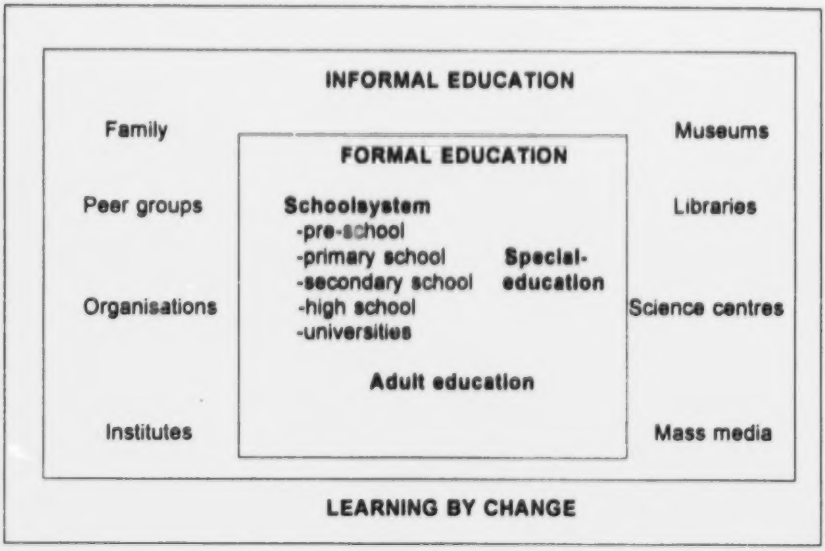
New methods are needed, as well. Observation methods, for example, are often designed for school, classroom or laboratory situations (Falk 1976; Evertson & Green 1986; Falk & Dierking 1992; Salmi 1992). Some approaches to this field have already been made (Lucas, McManus & Thomas 1986; Borun 1989).

1.2. The Terminology of Formal and Informal Education

The terminology of informal education is variable, due to, on the one hand, the slight difficulties caused by differences in school systems and, on the other, some translation problems. One of the main difficulties is that pure informal learning refuses to be categorised, and that definitions are not needed until informal learning becomes institutionalised.

The relationship between the different kinds of education is shown in Figure 1.A. (Alanen 1981;applied):

Figure 1.A: Formal - Informal education.



The figure 1.A. is combined from several sources: it was originally devised by Unesco, then used by Alanen (1981) to show the forms of life-long education.

Formal education is education given by specialised organisations representing the school system from pre-school to university.

Informal education is education given by different institutes, whose first function is not to educate: newspapers, television, libraries, youth free-time organisations, hobbies, peer groups and family.*

Self-education is included in informal education. A personal teacher is not needed; tutorial learning sources are used by the learner.

Learning by chance is learning that occurs without any conscious education or teaching, outside organised learning situations, mostly in every-day-life situations (cf. Krieck 1922).

Alanen (1981) adds one element to figure 1.A above: it is typical for formal education to plan and form connections between different schools and courses. In informal education, the links between different studies are not consciously organised.

---

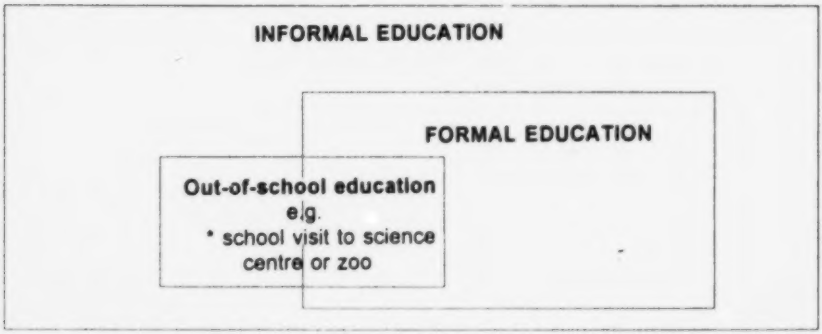
*The term "informal education/school" also has another meaning in educational terminology, especially in Great-Britain where the child-centered pedagogical movement inside the school-system and particularly in the primary school was named "informal education/school" during the 1960s and 1970s (Central Advisory Council for Education 1967, Galton 1980).

Non-formal education is also an often used term. It means any education that is organised and has clear goals, but occurs outside the official school system (Lowe 1975, 24-25; Peltonen 1981, 17; Maarschalk 1986, 353-360; Bishop 1989, 131; Takala 1989, 42-52). Non-formal education is most often used in connection with reading campaigns in the developing countries. When the term non-formal education is used, it does not include learning that takes place within the home, in factories, or through the media. For example, Bishop (1989), Maarsschalk (1986) and Peltonen (1981) clearly distinguish informal from non-formal learning. In this study, the term non-formal education is not used, because features defined under that term are included in informal education.

Out-of-school education

is yet another essential term. It means education that happens during school time and according to the curriculum, but uses settings and institutes outside the physical school building. Out-of-school education is also a term included in school legislation (see 1.3.; "koulun ulkopuolella annettava opetus"). Out-of-school education often uses informal education sources for formal education, as shown in Figure 1.B:

Figure 1.B: Out-of-school education as a link between formal and informal education



1.3. Out-of-school Activities as a Link between Formal and Informal Learning: Current Developments in Finland

In Finland, teaching has traditionally belonged to schools. However, school legislation has not forbidden the use of out-of-school activities within school education. The main argument was that they are refreshing rather than cognitive. The goals of traditional spring picnics and excursions, for example, are social rather than educational.

During the school reform in Finland ("peruskoulu-uudistus") in the late 1960s, some of the key aspects were co-operation and links between school and the surrounding society. It was emphasised that school is not the only factor that has an effect on children (Komiteamietintö 1970A, 20). However, few directions or orders were given. Field trips during lessons or longer excursions are mentioned (ibid., 177-78), but out-of-school

educational activities were not included in the strongly centralised school reform.

Symptomatically, the general curriculum has no recommendations or guidelines for out-of-school education, but the special curricula for different school subjects (biology, geography, etc.) mention out-of-school activities in their working methods (= "työtavat") in several contexts. For example, the religious-knowledge teaching methods clearly include a study trip (="opintoretki") to a local church as a form of education (Komiteamietintö 1970B, 249-250). The pressure from different interest groups (church, industry, cultural, sport and art organisations, language groups) has affected school education on many levels.

Industry and labour market organisations were worried about the lack of links between comprehensive school (peruskoulu) and real working life. The National Board of Education gave clear directions about how to introduce working life to pupils mainly during a period in the 9th grade of the senior level of comprehensive school (Kouluhallitus 1977; 1978). The TET-period (TyöElämään Tutustuminen; "Introduction to Working Life") was also included in the school legislation. This practice follows the tradition of apprenticeship learning (cf. Gardner 1991).

The TET-period had an important role as a forerunner for the use of informal education sources in formal education. In 1977, a working party called KOULKOP was set by the National Board of Education to study forms of out-of school education (Kouluhallitus 1978b). The working party's general direction and specific recommendations (Yleiskirjeet no. 2402, 2407, 2534, 2697) were compiled as a unit direction (Kouluhallitus 1979)

concerning out-of-school educational activities. Administrative directions were given, thus ensuring development and implementation.

The National Board of Education published a pedagogical booklet in order to help teachers plan and implement out-of-school educational activities. Reasons for using informal education settings were listed as follows (Kouluhallitus 1980):

- there is little interaction betweenschool and society, and this can be increased
- opportunities to apply school knowledge in practice
- teaching can be applied, in practice
- pupils learn to make observations and gain new experiences
- motivational factors.

The administration urged schools to take advantage of new opportunities for out-of-school education (Aho 1982, 2). The legislation concerning comprehensive school was renewed in 1985. The use of out-of-school education was one of the important reforms. According to the law, "peruskoulun opetusta voidaan antaa myUos koulun ulkopuolella (Peruskoululaki 1983/476: 26 § 3 mom)". (Transl: 'Comprehensive school education can also be given outside school').

In addition to the TET-period, ten school days during each school-year may be used for out-of-school education. During that period, exceptions may be made from the normal schedule and teaching hours (Peruskouluasetus 1984: 21 §4 mom).

A strong argument for the use of out-of-school education can be found in the school legislation. It is the teacher's duty (according to Peruskouluasetus: 21 § 4 mom) "to use and develop different teaching methods". The educational advantages are numerous. Out-of-school education gives opportunities for many-sided activities and integrated learning that combines different school subjects. Stimulating and affective teaching is easier in informal settings. The link between school and society can be strengthened. The pupils have opportunities for independent learning and for co-operation; and their motivation is increased. It is recommended that out-of-school activities should be used during normal lessons (oppitunti), in the form of short visits to exhibitions, industry, etc. (opintokäynti); a one or two days' excursion, a few days' camp school (leirikoulu) or in another form. The need for careful planning, safety and responsible supervision is emphasised. Local decision making and educational activities are essential. (Kouluhallitus 1985b, 41-42).

Almost the same principles and practical suggestions are repeated in the laws concerning the senior secondary school ("lukio") (cf. Lukiolaki 1983/477 § 2 , 18; Lukioasetus 1984/719, § 20, 89).

The law and statutes were supported by a new booklet. The rapid growth of knowledge is presented as a new challenge to formal and out-of-school education; and the schools' responsibility for facing this is emphasized. In addition, the opportunity to enhance school work is mentioned in the pedagogical goals of out-of-school education (Kouluhallitus 1986).

The use of informal education is one of the main trends in the recent development of schooling (Ruuhijärvi 1982, 3-6). The legislation for out-of-

school education can be seen as a reaction by the educational administration to some of the criticism of school. This criticism led to the situation where the principles and practice of informal education were integrated into school curricula. Of course, the use of informal education sources is not only a question of school legislation: the main thing is whether the teacher uses this opportunity or not.

1.4. Forms and Sources of Informal and Out-of-school Education

Some common sources of informal learning and their use in out-of-school education are only briefly discussed here. For example, books and libraries are excluded. These are both such large fields that they could be discussed as broadly as science centre education was in chapter 2.

The popularity of camp school ("leirikoulu") increased in Finland during the late 1980s. Its model came from Denmark, where pupils have a school camp at least twice during their ten years' compulsory school. At first, camps took place in the Fiinish countryside, but gradually cities and adjacent countries also became destinations for this period. Out-of-school education is also a question of money: in Denmark, pupils may travel on the railway free of charge (Lahdenperä & al. 1989, 13-15). Out-of-school learning has to be free for pupils in Finland as well. In practice, parents' associations often earn and collect money with pupils before the excursion. One of the recommendations made by the school legislation is that out-of-school education should improve connections between parents and school (Kouluhallitus 1985b, 42). Exact figures for the number of camp schools are still lacking (Lahdenperä & al. 1989, 16), but it can be said that the majority of pupils have at least one school camp during their school years.

Field trips, traditionally used in biology and geography teaching, are perhaps the most popular type of out-of-school learning (Balling, J. & Falk, J. 1981; Virtanen & Kankaanrinta 1989, 106-11). They are often used to teach art and especially sports, and depend heavily on the commitment of a single teacher and the opportunities available in the neighbourhood of the school. Visits to swimming baths are normally part of the curriculum in Finland.

The use of museum education in history teaching is common. All available opportunities are not taken, however, despite pedagogical recommendations and the availibility of good practical materials (e.g. Parr 1959; Suomen Museoliiton Julkaisuja 26/1982; Bay 1984; Madden 1985). Schools have also been an important target audience for art museums. "The Art Museum as an Educator" (ed. by Newsom & Silver) published in 1978 is one of the largest collections of pedagogical recommendations for informal education.

There are also several studies concerning the use of zoos in school education (Millman 1979; Ollason 1979; Rosenfeld, S. 1979; White & Herman 1979).

Mass media are perhaps the most important source of information for people. They are also an enormous source of informal education. Television, radio, newspapers and magazines are of key importance for learning even if political and social contents are excluded. Not only opinions but also factual knowledge concerning, for example, environmental (Kansallinen ympäristökasvatusstrategia 1992) and health questions are accessible through mass media.

In industrial countries, children daily spend hours in front of the television, sometimes even longer each day than at school. Most television watching is pure entertainment, but even then some learning occurs by chance. (Silvo 1985; Morley 1986; EFB 1990; Kasari 1990.).

One of the most dramatic examples of the power of informal learning can be found in Tallinn, Estonia, where many people understand Finnish, although it is only taught formally at the university philology level. The explanation for this phenomenon is the Finnish television programmes, which were the preferred choice of people in the greater-Tallinn area during Soviet rule (Meri 1992; Joerüüt 1993).

Television has also been used in school education. School television exists in most industrialised countries and can be used as a learning source and a way to enrich school teaching (Bates 1984, Patterson 1990; Scannell 1990; Auckland 1991; Hunkin 1991; Salmi & Hautamäki 1991). The use of other, general television programmes in education has increased considerably since VCR-equipment and interactive laser videodiscs became available (Hofmeister & al. 1989).

Newspapers are a very important source of informal learning. The use of newspapers in school-education has increased, especially during the recent rapid historical and social changes. The co-operation between schools, newspaper publishers and school administration has also increased recently in Finland (Linnakylä & Takala 1990; Järvenpää & Klippi 1991).

Industrial excursions are popular among pupils, mostly because they provide a welcome change from daily routines. It is, of course, useful to see real

working life (cf. TET-period in chapter 1.1.) but the interests of pupils, teachers and industry may differ (Jauhiainen 1992). Excursions are most important for vocational education. In many countries, industry has campaigned to clean-up and change its image for young people, to make a career in industry appear attractive, in order to recruit new man-power. From the point of view of industry, the science and technology curriculum at school is some steps behind technological change. In seeking to change attitudes, industry has looked towards informal education: effective methods are available, educational material can be produced, methods and materials can be integrated into the existing curriculum (TT 1987). According to Jauhiainen (1992), more effective learning results can be gained in chemistry education if prepared tasks based on the pupils own activity, are used during a visit to industry. There are also several international examples of this process (CRAC 1986; Warwick 1989; Bradshaw 1989). The main question remains: who controls education. The apprenticeship system has certain almost-forgotten pedagogical advantages especially in vocational education (cf. Gardner 1991). The main criticism against it has been its narrowness - the opportunity to learn only one working skill, and not an occupation. This was one of the reasons for enlarging formal vocational education during the 1970s and 1980s in Finland. The popularity of apprenticeship education ("oppisopimuskoulutus") as a part of formal education has now increased (Opetushallitus 1991).

Personal computers are the latest example of the power of informal learning. The rapid development of the PC has put pressure on formal education. For example, the directions given by the school administration had to be changed annually because of technical developments. The re-

education of teachers is unfortunately taking place too slowly. Most people still learn to use computers through informal learning sources.

One of Illich's basic concepts is thus a practical reality, working world-wide through computer nets, modems and electric mail. Computer-nets seem to be more effective than the formal school-system for teaching computer competence. However, it must be underlined that Illich (1971a, 115) refuses to use the term "network" (instead: "opportunity web"), because "network is often used, unfortunately, to designate the channels reserved to material selected by others for indoctrination, and entertainment". There are, of course, numerous controlling elements in computer nets, but that which it most resembles is the telephone net, which is also ranked highly by Illich. There are several examples of the use of computer technology in order to learn and create innovative educational activities without prejudice (Tuomi 1989).

Science centres are classified in the field of informal education with museums, libraries, art museums and mass media. But here is the dilemma: is science centre education really informal education? What happens when a child comes to a science centre as a pupil with schoolmates and a teacher, and not as an individual child of her* own free will? This question remains unanswered, although pupils clearly come eagerly to a science centre even with their schools. Does a science centre loose something of its strength as a source of informal education when co-operation with the schoolsystem starts? Science centre education is thoroughly analysed in chapter 2.

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* For expositional ease I vary the gender from now on.

1.5. The Dichotomy of Formal and Informal Education: The Context of the Study

Bitgood (1988) has collected a number of results from studies showing the differences between learning in informal settings and in formal institutions. Table 1.1. shows a detailed comparison between these two.

Bitgood's comparison of formal and informal learning is based on seven differences:

1. Instructional stimuli are, in informal education, more varied than in formal education. This may keep the visitors interested in learning, but there is a danger of information and effect overload. For children, the use of abstract ideas or symbols in formal learning might not have meaningful impact. Instruction is also a key element in creating motivation (cf. 3.5.).
2. Characteristics of the environment in formal education are planned to protect learning from external disturbance and to concentrate attention on instruction given by the teacher or by written material. The subject matter is often an essential part of the environment in informal learning settings. The balance between boring and over-stimulating environments is discussed in chapter 2.11.
3. Responses. Behaviour patterns are explicitly prescribed by the authorities in formal learning. In many informal learning settings there is not even a recommendation for the route or time to be taken. The situation specificity of responses becomes even clearer when informal settings are used for out-of-school programmes in formal education: pupils make a very clear distinction between "tasks" and "own time" during their school field trips (Hautamäki & Salmi 1988; see 2.11.).

Table 1.A: Comparison of Formal and Informal Learning Environments

Dimension	Formal Learning	Informal Learning
Instructional Stimuli	Verbal (lecture format) Visual (textbook) Sustained exposure to the learning material Exposure explicity controlled by the teacher Symbolic exposure to objects	Visual (Exhibit & labels) Short exposure to material Exposure controlled primarily by visitor Direct contact with objects
Environment	Learner stays in the same environment (classroom) Environment is highly structured (focus is on the instructional stimuli rather than the environmental features)	Learner constantly changes her environment as she moves from exhibit to next Environment is highly variable (focus is on the exhibits, often more than just the message).
Responses	Teacher paced behaviour Behaviour is strictly prescribed by the system (learner sit at desk and listens to teacher; completes text assignments; takes exams, etc. System monitors performance closely; criterion-levels carefully adhered to	Leisure (visitor paced behaviour) Behaviour is nonprescribed (visitor chooses facility; chooses pathways; leisurely walks from exhibit to exhibit, sometimes stopping; visitor looks, talks, touches, etc.) System places more emphasis on attendance; little emphasis on monitoring learning progress
Social Contacts	Teacher-student contacts are rigidly structured Lack of family social interaction Peer contacts common Learning is a nonsocial event	Usually little contact between the staff and the visitor Family social interaction is the form; less peer contact Learning is a more social event
Consequences of Learning	Consequences are often coercive (both the immediate and long-term effects of learning involve powerful consequences) Procedures include: reinforcers (e.g.,grades); response cost; punishment Contrived consequences	Noncoercive consequences (the visitor selects experiences; no obvious consequences if visitor fails to learn) Consequences are often positive (e.g.,enjoyment; exploration; social interaction; learning interesting information) Intrinsic reinforcers
Objectives	Quantity of learning emphasized Traditional body of knowledge (fixed curriculum) Verbal, expressive, analytical	Quality of experience emphasized Enjoyment (measured by verbal descriptions; time at exhibit; repeated visitations) Receptive, attitudional
Audience	Restricted by age and academic achievement	Unrestricted; mixture of ages and achievement levels

4. Social interactions between pupils are controlled by the teacher. Working individually is the norm in formal education. In informal education, learning is a social event where visitors exchange information (or misinformation) with one another, and parent-child interactions are very typical.

5. Consequences of learning. In formal education, students know that they will be tested. Grades and punishments are used as reinforcers. This has an effect on learning and motivation (cf. 3.1.-3.6.). Extrinsic positive consequences like enjoyment and social interaction are important in informal learning, but an overdose of them may prevent learning. The big challenge for informal education, the opportunity of changing the strong extrinsic motivation created by an informal experience (in this case a visit to an exhibition) into deeper intrinsic learning motivation, is one of the main subjects of this study.

6. The objectives of formal education are expressed in curricula, and most informal learning institutions have written educational goals. The increase in school visits to informal-education sites forces these institutions to create their own school programmes. Most of them encourage school visits. The hidden curriculum is one of the tools used to asses and criticise schools (Illich 1971a; Silberman 1970; Broady 1981), but it would also be extremely useful to make such an analysis of informal education institutions, which are themselves not devoid of social or value context (Salmi 1992b). Bitgood (1988) made a provoking dichotomy by identifying formal learning with quantity rather than quality of learning.

7. Audience most clearly distinguishes between formal and informal education. The target audience of formal education is selected and homogeneous, while the audience for informal learning is highly variable. No wonder that audience surveys are the most common topic of informal education research (cf. 2.11.).

Formal and informal education are often presented as being in conflict. Bitgood's (1988) comparison above is a dichotomy, which shows that the two have many features in common. The common features become even more prominent in out-of-school learning, when schools use informal settings as tools for education.

As mentioned earlier (see page 6), the term 'informal education' has a second, narrower and more specific meaning. In Great Britain, the child-centred education ('progressive pedagogy') movement within the school system became known as 'informal education' or 'informal school'. The principles of this movement have much in common with the learning that happens outside school. This is no surprise, because the movement originated in the war years of the 1940s when children with their teachers were evacuated from London to the countryside. Teachers had to develop new methods because of the large groups, lack of materials, etc.: timetables with formal 45-minute lectures were replaced by simple daily routines and every-day-materials; and teachers took advantage of the environments they found. Some teachers continued to develop these experiences when they returned to their city schools (Galton & al. 1980; Hytönen 1992).

One of the key elements of the 'informal school' was a child-centred approach in all teaching. 'Informal school' tried to individualise learning, to give direct experiences of the subject and to offer opportunities for creative investigation. The pedagogical goal was to avoid dividing knowledge into separate boxes, and the approach was characterised by the use of innovative learning methods (Central Advisory Council for Education 1967).

The pedagogical principles of 'informal school' are very close to those applied in science centre education. The experience of applying them in schools, in the late 1960s and 1970s, has given relevant and valid results. However, the main question of the substance of informal learning and education still remains.

It is typical that criticism of the so called "Black papers" (1969-1977) was directed towards the radical and political aspects of the 'informal school' movement, and that the real weaknesses and strengths of informal pedagogy were more or less excluded from the discussion, as Hytönen (1992) points out. Once again, informal learning was used more as a tool of educational criticism than as a practical means of improving education.

In this study, science centre learning is analysed both as a representative case of informal education and as an opportunity to apply out-of-school education methods.

The prime focus of this study is the relationship between motivation and learning. Meaningful learning and deep versus surface learning are evaluated. Personally defined goals are important for meaningful learning. The learning of concepts, encouraged by intrinsic motivation, can lead to deep learning instead of the surface learning easily aroused by extrinsic motivation. Although well-structured process is of importance in informal learning, the elements of curiosity and imagination are arguably of greater significance (cf. Dewey 1938; Illich 1971a; Marton 1980; Vygotski 1982; Bruner 1986; Minsky 1986; Gardner 1992).

2. SCIENCE CENTRES

Why is the sky so blue? What is the explanation for the cycle of day and night? How old is that cave painting? Interesting questions, and man's instinct to investigate the world around him is the basis of the development of science.

Human beings have always wanted to know things and find explanations. They have also wanted to share the information with the others in an oral or written way. The exhibition is a rather new way of transferring information.

2.1. The first visions

The oldest plan for a science centre can be found in the writings of the philosopher Francis Bacon (1561-1626). He was one of the first developers of the empiric scientific method - the principle on which the ideology of science centres is based.

This spirit can be found in Bacon's proposal for a museum of discoveries and a gallery of the portraits of great inventors. The main idea was to demonstrate the importance of mechanics and sciences by showing respect for the scientists. This was to be done by combining the worlds of art and science (Gregory 1986; Hudson 1988).

In addition to this concrete exhibition plan, Bacon has become perhaps even more famous for his description, in his book "New Atlantis", of a

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journey to an imaginary land, where the visitor was able to go to "Solomon's House". This four hundred year-old text still qualifies as a good science fiction story:

...perspective-houses, where we make demonstrations of all lights and radiations; and of all colours; and out of things uncoloured and transparent, we can represent unto all several colours; not in rainbows, as it is in gems and prisms, but on themselves single. We represent all multiplications of light, which carry to great distance, and to sharp as to discern small points and lines; also all colourations of light: all delusions and deceits of the sight, in figures magnitudes, motions, colours: all demonstrations of shadows. (Francis Bacon, New Atlantis, 1667; in Gregory 1986).

The text goes on to describe vividly the worlds of sound, engines, mathematical instruments, geometry, astronomy and much else. The text also indicates that the idea of demonstrating scientific phenomena is not new, but not so ancient either: the tradition began only three or four hundred years ago. Bacon's precise and imaginative description has inspired the planners of modern science centres as well (cf. Gregory 1986; Kurenniemi & Hautamäki 1988).

In addition to Bacon, many other great scientists since the Age of Enlightenment have outlined their ideas for science exhibitions and museums.

René Descartes made a proposal for a museum presenting scientific instruments and mechanical models. It was not realised, but his writings and plans survived over a century and led to the establishment of one of the first science museums: the Conservatoire des Arts et Métiers in Paris in 1794.

Gottfried Leibniz's idea went many steps further. His plan for a science exhibition and museum embodied the principle that the exhibition should, while demonstrating scientific phenomena to the public, also entertain and enlighten people. Leibniz included many practical examples for the contents of the exhibition: Magic Lantern, optical illusions, large-scale globe model, muscles, bones and nerves, etc. (Danilov 1981). What makes Leibniz's idea revolutionary is the fact that he intended the exhibition to be for children, and to be used 'hands-on' by them. He not only raised new pedagogical questions in relation to children, but also outlined the didactic principle of modern science centres - three hundred years before their origin.

Benjamin Franklin is yet another scientist who emphasised the popularisation of science using models and exhibitions. As a result of his work, The American Society for Promoting And Propagating Useful Knowledge was founded in 1768. The science museum and centre in Philadelphia also carries Franklin's name (Franklin Institute 1989).

2.2. The Technical Model Chambers and Science Entertainers of the 1700s

The roots of science museums are to be found in the numerous exhibition cases of the 17th and 18th centuries. These exhibitions were owned by rich Maecenas, who collected technical and scientific models. The Instituto e Museo di Storia della Scienza, for example, exhibits the scientific treasures of the Medicis, including the original telescopes handmade by Galileo.

In Sweden, Christian Polhem (1661-1751), the inventor and engineer, designed hydraulic elevators for the mines of Falun and planned the Svea channel: he wanted to open an exhibition of technology and machines linked to his laboratory. The idea did not become reality, but the models that he donated formed the Royal Model Chamber exhibition. Today the exhibition is still alive and popular with visitors (Larsson 1984; Heureka 1990).

Royal families and wealthy rulers have played an important part in the foundation of all kinds of museums. In many countries, the typical museum presented the country's glorious history and art with the portraits of its monarchs.

A very different style of science popularisation developed in Britain during the 18th century. Scientists and inventors travelled the country giving lectures. At first these lively demonstrations were part of the serious formal in universities, and were also given on special occasions. But very soon they became a regular spectacle at all kinds of popular gatherings and fairs, where the lecturer animated his show with models, motors, air and hydraulic pumps, etc. Such models were also manufactured for rich people to use at home (Hackmann 1988).

These demonstrations, originally performed by travelling lecturers, are also described in official university course books. The demonstrations and ideas soon became familiar outside Britain: the Swedish scientist Mårten Triewald, who studied in England in 1716-26, collected a large book of demonstrations after returning to the university of Lund (Larsson 1984).

So the circle is complete: a model originally made for popularising science had found its way to a university course in another country!

Industrialisation gave birth to the Great World Expositions, which presented the latest technical and industrial achievements, often in a spirit of nationalism and supported by art. These expos were very popular and even financially successful. Following the success of the Crystal Palace Exhibition in 1851, the South Kensington museums (today the Science Museum, Natural History Museum, and Victoria & Albert Museum) were establish, appropriately on Exhibition Road.

The same process happened after other World Expositions, too. The roots of most of the important science museums founded in the second half of the 1800s are to be found in the Great Exhibitions: the Bohemian Industrial Museum (later the National Technical Museum) in Prague; the Technological Museum Of Industry, Crafts, and Trades in Vienna; the Smithsonian Institution's National Museum and its Department of Arts and Industries in Washington D.C.; and even the Deutsches Museum in Munich, can all trace their original collections, funding, ideas and key people to the big exhibitions (Danilov 1982, Hudson 1988).

The same trend has been important for modern science centres a century later: the Museum of Science and Industry in Chicago was started in a pavilion built for the world expo forty years earlier, and the Pacific Science Centre, got part of its exhibition from the U.S. science department of Seattle Expo 1962. The Exploratorium science centre, opened in San Francisco 1969, is still housed in the Panama-Pacific World Exhibition Hall of the year 1915. Halls and exhibits originally

made for the world expos are still, in the 1980s and 90s used by science centres (e.g. Osaka and Seattle).

This trend is not a coincidence. In the same way that the national museums and galleries grew up from a need to support the state and nationalism with heroic wars and historical knowledge, so, during the time of rapid industrialisation, the development of technology and new inventions made it possible to use technology as a tool for nationalism. International trade was important for the state, but even more important for industry and the new manufacturing companies. This double need for the marketing of science, technology and production, provided the rationale for establishing many science museums and modern science centres.

2.3. The Museums of Science in the 1800s

The museums of science and technology have their own interesting background. The early name often used for these institutes, Cabinets of Curiosities, describes them well, and they very soon became institutionalised (MacGregor 1987, 147-156; Hunter 1988, 158-168; de Clercq & t'Hart 1989, 12-14).

The Ashmolean Museum is often considered to be the first science museum. It was founded in 1683 in the University of Oxford to house Elias Ashmole's collections of natural history. The museum still operates as the museum of the history of science in Oxford, having a fine collection of scientific instruments dating from medieval times (Hudson 1988).

The first large scale museum of science and technology was the Musée National des Techniques, opened in Paris in 1799. Descartes had created the concept of the institution, as described above, but the museum itself could not be build before the ideas of the French Revolution became widely accepted. Its purpose was to use the collections in order to communicate to teachers, students and the general public the most important aspects of science and technology. However, like many other early technical museums, it has became "old-fashioned" and more like a historical museum than a contemporary educational institute (Hudson 1988, 88-90). With the rapid development of science and technology even the newest science centres, opened in the 1980s, are rapidly becoming 'old-fashioned'!

The Science Museum in London grew from the South Kensington Museum that was opened in 1857. At the time there was no concept, in England or elsewhere, of a museum of science in the modern sense. It was primarily an educational institution, with a target audience of teachers and skilled workers (Hudson 1988, 91).

In 1876, a Science Exhibition was arranged in the museum of South Kensington. For the very first time, ordinary people could see scientific instruments of many kinds; methods and theories were presented systematically. However, the museum could not maintain this function and due to lack of resources it became more a library of objects, with a huge and remarkable collection, than an active educational institution. In the 1920s and 1930s the opening of the Children's Gallery at the Science Museum influenced education in British schools, and the development of many museums in the world (Hudson 1988, 92-93).

At the same time, important developments occurred in Vienna and Prague, as mentioned above. In the U.S.A., the main efforts were made by the Franklin Institute in Philadelphia and the Smithsonian Institution in Washington D.C. (Danilov 1982; 1990).

2.4. The First Science Centres in 1920-40

The **Deutsches Museum** in Munich is often held up as a prototype of the modern science centre. It was started in 1903. During its first decades it was located in an old building, until a new museum was built and opened on an island in the river Isar in 1925. It was an exceptional project right from the start: Oskar von Miller was a strong personality with a clear vision for a new type of science-technology museum. He was also a skilled politician and the project became one of national significance receiving wide support from the German government, the Bavarian state, the City of Munich and German industry (Von Miller 1927).

The Deutsches Museum has today grown into a huge complex with over 40,000 square metres of exhibition halls and over 10,000 different exhibit units.

The Deutsches Museum was unique, and made according to Oskar von Miller's plan for a museum of the master-works of natural science and technology. The most obvious difference between this and earlier museums was that it contained many examples drawn from contemporary science and technology, although the exhibitions also included examples from the 14th century. But the radical innovation was the models, exhibits and demonstrations, which visitors were allowed to touch and were able

to use by themselves. The museum created, right from the start, a new medium of communication: the interactive exhibition.

In addition to von Miller's commitment to advancing the status of technology by showing its fruits and making it more attractive, the main aim of the project was to civilise people. The exhibitions had to be open to everyone - not only specialists and technically-oriented people. The contents were planned in order to give visitors an overview of the effects of science and technology on the history of mankind and on everyday life at the time (Danilov 1982).

The museum was, at the beginning, meant only for adults, but as increasing numbers of teachers visited, its audience very rapidly expanded to include the school visits (Hudson 1988).

The Deutsches Museum was a forerunner. It also started the first planetarium in the world in 1925. The planetarium provided brand new equipment to teach astronomy and to demonstrate astronomical phenomena, planets, stars, the moon. Planetaria became common before the Second World War, and were often situated near science museums (Hagar 1980, 94-97).

The **Museum Of Science and Industry in Chicago** is a direct descendent of the Deutsches Museum. Many of its ideas and demonstrations originate from Germany. Victor Danilov (1982) has described this process very clearly.

There was social demand for a modern science museum in the U.S.A. in the 1920s. The pace of development in the first decades of the 20th century propelled the USA into a leading position in the world, both in the field of scientific research and, especially, in the application of science to industrial production. *This development is reflected in American museums.*

The link became clear when the first full-scale science and technology museum was established in the U.S.A. in 1929. The Henry Ford Museum's mission was to preserve and to cherish American history and heritage. History was viewed from the perspective of technology, inventions and applied science. Thus the nation was presented in the light of the effects of technology on every-day-life (Danilov 1982).

The director of the American Association of Museums (AAM), Charles Richards, demanded that a truly scientific museum be established in the U.S.A., immediately. His main goal was to show that the roots of the nation are planted in technical know-how, and in the application of new ideas and innovations. He also pointed out the project's new educational approaches, which were later more specifically analysed by Charles Gwynne (Danilov 1982).

Gwynne made a report (also in the form of the movie "Museums of the New Age") on the contemporary museums in Europe. One of his main observations was the support given by universities and scientists to museums in Europe. American museums lacked this support and as a result their contents were more superficial.

In European museums, moving exhibits and mechanical models made the exhibitions attractive. This new trend, and the opportunity of touching the exhibits was interesting. Gwynne (1927) underlined the principle of "learning by doing" as a progressive change in museum pedagogy (Melton 1935; Melton & al 1936).

Gwynne's report had great influence on the development of museums in the USA, and the change in their character. One direct effect was the founding of the New York Museum of Science in 1935, after some test projects and preliminary exhibitions (Danilov 1982).

During the period 1925-35, a new form of pedagogical thinking developed and became more and more evident in the new science museums: interactive models, demonstrations, objects to be touched, lively exhibits and educational aspects were now considered important. The famous "hands-on" principle was born during that time, at first as a slogan to contradict the traditional "hands off!" signs in museums.

The origins of the hands-on principle can also be traced to educational philosophy during the late 1920s and 1930s. In educational science and in the renewal of the school system in the USA, two people were particulary important: John Dewey and William Kilpatrick. They both underlined the importance of the activity of the learner, together with the teacher's and school's role in using this activity in the right way.

Kilpatrick's (1926) key idea was the pedagogy of work: meaningful work is the way to learn and teach. Dewey's (1936; cf. Bowen & Hobson 1988; 162-215) principle of "learning by doing" contained a deep analysis of

crucial points in the learning process, and of the way in which teaching must be structured to make learning most effective. The theoretical understanding of a phenomenon is possible only through practical work and the study of the subject. The learning-by-doing principle has an in-built element of scientific method and process. Dewey also emphasised the affective element and the role of motivation in learning.

The **Museum of Science and Industry in Chicago** played an important role as a model for several other science centres, both in the U.S.A. and elsewhere in the world. Despite its name, it is not merely a museum conserving historic objects. Hands-on models and interactive exhibits are an integral part of its mission.

The influence exerted by the museum has been due, not only to its new ideas, but even more to its effectiveness in realising them. Very open politics concerning the ideology, management and fundraising appropriate to new science museums, established the museum as a leader in the field even more than its size, visitor numbers and the quality of its exhibitions. This position was reinforced by the publications of Victor Danilov, the long-term director of the Museum of Science and Industry. His books Starting a Science Centre? (1977) and Science And Technology Centres (1982) are recognised as classics.

Although the Museum of Science and Industry has been a model for many other science centres, it borrowed its first ideas from the Deutsches Museum. The founder of the Museum, Julius Rosenwald, acknowledged that he found inspiration for the institution during a summer-holiday visit to the Deutsches Museum, Munich. Rosenwald went, according to his

report, to visit the museum after his eight-year-old son eagerly described the museum's interactive exhibits (Danilov 1982).

Rosenwald had three arguments in his campaign for the museum in Chicago: 1. The museum would give entertaining information about science and technology to ordinary people. 2. The museum would offer students, technical workers and even scientists, excellent opportunities to expand and integrate their knowledge, through its new way of exhibiting phenomena. 3. For young people, the museum would be an inspiring and educational place to visit. (Danilov 1982, 25).

The educational role of the museum was important. The target audience was ordinary people, not merely the academic audience already interested in the subject, as was (and is) the hidden trend in most museums no matter whether they exhibit history, art or natural science. The Museum of Science and Industry succeeded in its mission to be a museum for everyone, maybe better than any other institution before it. The main reason for this success was the conscious investment of bright ideas and innovations, both in exhibition contents and in the vivid and interesting design style of the exhibits themselves (Danilov 1982, 25-27).

The completion of the Museum of Science and Industry took more than two decades: Rosenwald had his first idea in 1911, but the museum was incorporated only in 1926, and opened in 1933 (Danilov 1982, 23-27). The same problems had to be solved as in nearly all science centres since then. The original concept had to be followed by: fund raising, finding a location, building, administration, raising support from the local society,

securing running costs after opening and, last but not least, the processes of planning and generating interesting ideas for the exhibition.

Some other important institutions were established in the USA in the first decades of the 1900s. The Henry Ford Museum and the New York Museum of Science have already been mentioned.

The Franklin Institute had several educational projects such as a special school, public lectures, science workshops and temporary exhibitions throughout the 19th century. In the 1920s, the Institute decided to start a project for a large science and technology museum. The Franklin Institute Science Museum was opened to the public in 1934. Its main purpose was to support and complement school education, as well as to recruit people to adult education. The exhibition consisted mainly of a collection of historical objects, including some classic masterpieces by Thomas Alva Edison, Michael Faraday, Vladimir Zworykin and, of course, Benjamin Franklin, but it also had many interactive exhibits and models. The natural history museums and institutions nearby dictated the focus on physical science. The first planetarium in the USA was also started there (Franklin Institute 1989).

The Palais de la Découverte (The Palace of Discovery) founded in Paris in 1937 is, arguably, the first modern science centre, although the Deutsches Museum and the Chicago Museum of Science and Industry were important landmarks in the development of the science-centre concept. The role of the Palais is, however undervalued in the literature (Hudson 1988, 100-105).

This institution broke with the past in four ways (Hudson 1988, 95-105): 1. It had no historical artifacts. 2. All exhibits, exhibitions and demonstrations were designed to describe modern science and technology. 3. The role of guides or explainers ("animateurs") in the demonstrations was emphasised. 4. The clearly stated and principal mission of the institution was educational.

Although the Deutsches Museum and the Museum of Science and Industry in Chicago presented innovative exhibition techniques, one of their main aims was to tell the history of science. The Palais de la Découverte, in contrast, concentrated on the present and all things modern.

It was also an institution that did not call itself "museum" - the trend that is now familiar from science centres that do not call themselves museums, but instead have names such as Exploratorium, Impression 5, Heureka, Eksperimentarium or Inventorium (ASTC 1990).

The Palais de la Découverte started as a temporary fair but almost immediately became a permanent exhibition because of the popularity of the temporary event.

Another significant difference between The Palais de la Découverte and its contemporaries, was its more consciously defined purpose. The emphasis was more on basic science than on the applied sciences or technology (Palais de la Découverte 1985; Hudson 1988, 104).

The Palais de la Découverte was the first science centre that unashamedly took education as its main purpose (Hudson 1986, 103). The whole concept of the institute was formed around the idea of education, from the youngest child to the oldest adult. Both the exhibitions and the demonstrations given by guides were planned from an educational point of view. The main support for the institution was (and is) from the Ministry of Education; and the universities of Paris support the planning and up-dating of the exhibition contents.

Most of the exhibits were (and are) equipment for the demonstrations given by guides ("animateurs"), who are university students, lecturers and other scientists. In a typical demonstration, the guide displays and describes a phenomenon for the public. During and after the demonstration there is the opportunity for direct interaction between lecturer and audience (Palais de la Découverte 1985).

The supplementary training courses for teachers, the high level of school visits, the lecture-demonstrations, the planetarium and the popular science publications all emphasise the educational basis of the institution (ibid.).

2.5. Science Centres in 1950-1972: The American Era

During the 1950s the development from science museums to interactive-style science centres was slow, although the technical development of industrial society was rapid. The change occurred in the beginning of 1960s.

The attitude towards the studying and the teaching of science changed dramatically in the USA as a result of the so-called Sputnik phenomenon. In 1957 Congress passed the National Defense Education Act (NDEA). The educational system in the USA was totally reformed. Science education was seen as an element of national security, in relation to the Cold War and the space race. Federal governments gave resources to local school administrations for the improvement of education. The scholarship system was renewed. Some scientists were enlisted to develop new curricula and learning materials for schools and to re-arrange teacher education. Resources were directed to pedagogical development projects as well. (Bruner 1964; Altbach & al. 1985; Kelly & Seller 1985; Ravitch 1983; Friedman 1989; Hein, H. 1990).

Although there were several important projects during the 1960s, much of the boom of the new science centre ideology is attributed to Professor Frank Oppenheimer. He first worked on the Physical Science Study Curriculum (PSSC) and Elementary Science Study (ESS) projects, developing science education, in reaction to the Sputnik phenomenon. Later, he started to develop a new kind of a science centre - The Exploratorium (Hein, H. 1990, 13-15).

In the late 1960s two important science centres were opened, and they influenced all subsequent science centre projects worldwide. The Exploratorium in San Fransisco in 1969 and the Ontario Science Centre in Toronto also in 1969. These "were the first of a completely new kind of institution with a truly hands-on approach to exhibition/education" (Quin 1991, 1). This quote undoubtely summarises general opinion concerning the development of modern science centres, although some

other projects, including the John Young Science Centre (the first one using the name of science centre instead of museum in the USA), were started even earlier in the 1960s.

Oppenheimer was very well aware of the development of the science museums in the 1930s discussed earlier. However, working from the basic principles, he created a new concept for a science centre, and proceeded to realise it.

Oppenheimer re-created the core concept of the famous American psychologist and educator John Dewey. Dewey's much quoted idea of "learning by doing" was also Oppenheimer's key concept. In his work it became the so called hands-on principle. A Rationale for a Science Museum (Oppenheimer 1968) is the manifesto for a modern science centre.

Oppenheimer criticised American schools for teaching basic science inefficiently and in misguided ways. Even simple phenomena were taught with books, words and pictures, or by the teacher's description, whereas they could very easily have been demonstrated or experienced by the pupils themselves (Hein, H. 1990, 13-17).

He criticised society's weak understanding and appreciation of science and technology and demanded firm action to improve the situation. Another even stronger criticism was directed towards "the passive pedagogy" (Oppenheimer 1972, 1973). This criticism included many of the same arguments as that were raised by the so-called Sputnik phenomenon against the whole American educational system.

Oppenheimer concentrated on the question of the role of museums and science centres in science education. He wanted to find the particular educational factors of an exhibition, and not to reproduce what could easily be done in school. The Exploratorium was planned "to provide opportunities for education that are difficult to achieve in school classrooms or through books, films, and television programs" (Oppenheimer 1972, 978). This formulation of the educational goals of a science centre can be found, stated in different ways, in the aims of most of the institutions established after the Exploratorium.

The quote above underlines the position of science centres in the spectrum of formal-informal education. First, the science centre is "providing opportunities for education". Second, it is not competing with schools but supporting or broadening the provisions of the school curriculum (cf. "difficult to achieve in school"). Third, it is one amongst many other opportunities for informal learning (television, films, books). The list could very easily be extended by adding: museums, libraries, newspapers, peer groups, family and many, many other communication media (Oppenheimer 1972; Hein, H. 1990).

Science centres can also influence, and have influenced, schools. This link is emphasised by some science centres (for example the Ontario Science Centre, Toronto, and Science North, Sudbury), whose activities include "outreach programs".

Oppenheimer did not exclude this kind of work from the tasks of a science centre; however he focuses on the characteristics of an exhibition. "Sight-seeing" is a term normally used for watching something from

outside. Oppenheimer gave a new, positive, meaning to this term in the context of an exhibition. After having analysed "sight-seeing" as a valid scientific method used by Darwin as by modern high-energy physicists, he criticizes "sight-seeing" when applied in the wrong educational sense. The learner must have the oportunity to interact with the environment. He defines it in this way: "The best kind of sight-seeing involves some exploration and the freedom to decide what not to investigate and where to linger. The more one can become involved with the sights through touching, feeling, smelling, and activity, the more rewarding it can be." (Oppenheimer 1972, 979-80).

Despite his criticism of school and formal teaching methods, Oppenheimer was eager to find effective models for co-operation between schools and informal institutions, for example by having a "museum district" in a city in the same way as a school district. These two cultural and educational systems should form a network to combine their characteristic features (Oppenheimer 1972). This idea resembles Ivan Illich's theory of educational webs, where information and skills are learned and taught according to personal needs (see 1.2.).

The tradition of developing and evaluating exhibitions is young. Oppenheimer underlined, in several contexts, both the importance of simply watching the exhibition visitors, and of making analytic observations of their behaviour (Silver 1978).

The science centre guide has many different names, even in one language. In English we find the terms guide, explainer, interpreter, blue coat, assistant, host, and even docent, which all describe (with slight or no

difference) the same profession of telling visitors about the science in the exhibition (Grinder & McCoy 1989), and of making the science centre a welcoming place with a human face (Quin 1990).

The role of exhibit-interpreter developed from early experience in hands-on exhibitions: it is very difficult, and unnecessary, to lead a guided group through an exhibition, because different people want to spend different amounts of time with different exhibits, or because their interest is orientated to objects other than those included in the guided tour (Oppenheimer 1972, 980; Cleaver 1988; Grinder & McCoy 1989).

The origins of the exhibits at the Exploratorium are very much in the models that Oppenheimer developed during his work with students in his career at the University of Colorado. He already had a large collection of models and experiments (Oppenheimer 1974), and very often all that was needed was to make them more robust for public use. Ideas for new exhibits, and techniques of design and fabrication, were collected from several sources: scientists, industry, artists and federal agencies.

Criteria for these - at first about 200 and now over 500 (Hein, H. 1990) - exhibit units is that they have to be participative and designed to be manipulated. No artifacts are exhibited. Individual experimentation by all age groups is emphasised and the key method of learning is thropugh multisensory feed-back from the exhibit (Oppenheimer 1968).

These exhibit models have been widely copied, refined and used in numerous science centres all over the world. One reason for this is, of

course, their innovative ideas and practical technical designs. Another reason is that the principle of scientific openness was applied at the Exploratorium right from the start: the ideas and designs were everyone's property. A book called Exploratorium Cookbook was published to spread the ideas (Exploratorium 1976), and many of the exhibits it describes (and gives fabrication instructions for) have become the 'classics' of modern science centres.

The Ontario Science Centre in Toronto (OSC), founded in the year 1969 like the Exploratorium, started another kind of 'interactive' tradition. Visitor participation and interactivity are the key concepts of in this science centre, too. By having no artifacts, it critised indirectly (and, in its written principles, directly) the presentations of historic museums (Ontario Science Centre 1972).

The OSC was built for the official Centennial of the Province of Ontario and Canada's Confederation. During the planning process the concept of "another science museum" was radically changed. "Emphasis was put on interpretative exhibits of scientific principles and technological achievements" (Ontario Science Centre 1972, 1).

Again the principles had much in common with the science popularisation tradition discussed above in connection with early historical proposals, first science museums and exhibitions of the 1930s. The statement "For people of all ages the Centre's concern is to illustrate how the application of science and technology affects their lives and their environment, for better or worse (Ontario Science Centre 1972, 1)" adds the idea of critical analysis to earlier formulations of the purpose of a science centre.

Several factors make the Ontario Science Centre important for later developments. First, it drew a clear boundary to separate itself from museums. Second, it included not only physical sciences and technology in its exhibitions, but also biology, medical science, Canadian nature, astronomy and space. Third, the architect designed the building to be a science centre from the outset (Ontario Science Centre 1972, 2-6; Danilov 1982, 37-38; Hudson 1988, 172-73).

Great commitment by the local community made it possible to integrate the core elements of the OSC's 'ancestors', whether science centres, museums, education institutions or special exhibitions. The scientific community contributed expertise to the contents; the site and architectural plans were chosen specially for the project; it received financial support from the provincial Government, the City, and also private capital; and all available knowledge of exhibition design and technique was drawn on.

The building has three Exhibit Halls. When the OSC opened, the themes of the halls were: Exploring Earth, Exploring Space, Exploring the Molecule, Hall of Astronomy, Atom Gallery, Hall of Technology, Hall of Transportation, Science Arcade, Hall of Communication, Hall of Life, Energy Mezzanine, Canadian Resources, Environment Earth and Solar House.

Mini-theatres and demonstration laboratories (over thirty all together) complement the exhibitions. A film theatre formed part of the OSC concept right from the beginning.

Educational programs were intended mainly for children, but courses were also arranged for adults. Large-scale school use was integrated at local and state level. A special science school for high school students was started (attached to the science centre) to develop science education even further, and to give selected pupils a head start in scientific careers (Wilson 1979).

2.6. The Era of Rapid Growth and Establishment: 1975-1985

The history of science centres has been introduced in the previous sections by some remarkable examples. However, many important institutions have been excluded from that overview in an attempt, simply, to show the main trends. At present there are approximately 500 science centres in the world. Most of them are members of one or more of the following organisations:

The Association of Science-Technology Centres (ASTC) was founded in Washington DC in 1973 for the professional organisation of museums and centres interested in communicating with the public and increasing understanding and appreciation of science its technological applications. The purpose of ASTC is to be "a not-for-profit organization of science museums dedicated to furthering the public understanding and appreciation of science and technology" (ASTC 1990, ii).

The characteristic features of members of ASTC are participative exhibits, demonstrations and hands-on experiences. Centres also serve as a resource for schools and other educational institutions. Pupils and students are their target audience (ibid., 1-7).

In beginning, there were about thirty founding member institutions and by the year 1987 the number of ASTC members had increased to over 320 in 35 countries (ASTC 1990).

Although the ASTC is an international organisation having associate members from five continents, its operations are focussed on the USA. In the late 1980s, two new organisations for science centres were founded.

National Council of Science Museums (NCSM) in India has developed a network of four (Calcutta, Bangalore, Bombay and Delhi) major and other smaller science centres. These centres are strongly oriented to education and have large-scale outreach programmes: they aim to establish a thousand school science centres (Quin 1991).

The European Collaborative for Science, Industry and Technology Exhibitions (ECSITE) started in 1989 as a collaborative association between European institutions. At present it has 25 European members and around 80 associates worldwide, and its activities are growing in scale. Its role has expanded from that of an ideas forum to a coordinator of concrete co-operations. For example, pan-European travelling exhibition projects were initiated in 1992 (ECSITE 1991).

The Nordic Science Centre Association (NSCF) was established following informal co-operation between the rapidly growing science centre projects in Norway, Sweden, Finland and Denmark in 1987. By

1991 there were about twenty science centres in Scandinavia, visited by over two million people during 1990. NSCF promotes co-operation between the centres: education, exhibit planning, design and marketing have been topics of the discussion meetings. The members have also exchanged exhibitions among each other (NSCF 1990, 6-35).

Danilov (1982, 42-50) classifies science centres into three types:

1. Comprehensive Centres are usually large, full-service contemporary science and technology centres having a longer tradition as a museum. These centres are divided into three categories: a) Industrially oriented centres, b) Educationally oriented centres and c) Scientifically oriented centres.

2. Specialised Centres have defined their purpose in one scientific theme only, for example health, energy, transportation, space, or nature. Centres grown around some local feature also belong to this group. These centres are modern, interactive (not necessarily hands-on) and educational, oriented both to schools and public understanding of science.

3. Limited Centres are often smaller in size and have fewer, selected exhibits than large, comprehensive centres. Some centres have started this way and grown into comprehensive centres. Traditional museums, which have developed some functions and departments in a participative direction are included in this category (Danilov 1982, 48).

In the ASTC Survey of 1990, the science centres are classified into five types: 1. Interactive science centres of hands-on exhibits. One third of the

centres in the survey are of this type. 2. Classical museums of natural history or science, which have developed some interactive parts. These form another third of the sample. 3. Interactive nature centres (approximately 10% of the institutions). 4. Children's museums (10%). 5. Health and medical centres (3%). (Grinell 1990, 2).

Those two analyses show much overlap, and they illustrate the main trends in science centres. However, as far as this study is concerned, neither analysis is perfect and some questions arise concerning their definitions and classifications.

Danilov's practical definitions still make sense. However, some aspects must be analysed. First, the size of the centres is overweighted in his classification. Even the biggest of the centres exhibit only small fragments of the field of science. Second, many of the comprehensive centres (with large numbers of exhibits concerning the history of industry and technology) might equally be classified as "limited centres" given the 'limit' of their subject areas.

In the ASTC 1990 survey, children's museums are defined in a class of their own. The main argument for the category is the target audience. In the same way, some of the institutions could be defined as adults-only museums. Nevertheless, over half the answers to the survey indicated that reaching children was one of the institution's three main missions. It is also strange to have a category for health centres, but not for other specialised centres. But, as indicated, the value of the survey is more in showing trends than in making strict classifications (St. John & Grinell

1990). It also illustrates the many different criteria that can be used in analysing science centres.

In 1987, ASTC carried out a survey of its members and twenty other institutions. The survey did not cover all the members, but the sample of 187 centres and museums, including 37 outside the USA, represented the field well (St. John & Grinell 1990), although new institutions in Britain and in Scandinavia are excluded from the survey because they were so recently opened. The situation and trends in modern science centres are described below on the basis of that ASTC survey, but some clear exceptions are identified to show the opportunities for developments in new directions.

Grinell & St.John (1990) identified two main trends during the period 1973-1987: diversity and growth. Clear differences can be seen in size, structure, focus and activities. The growth is not limited to the number of institutions: operations in addition to the basic exhibition vary greatly in type and number.

The size of the centres is very variable. Size can be classified by figures of space, budget and attendance. Of course the big institutions spend more money and can accommodate more visitors, but the link is not always self-evident. For example, some older centres do not need to make new investments in infra-structure, whereas others are spending heavily to renew old-fashioned exhibitions. The number of visitors is more and more related to marketing.

A few mega centres (over 10 000 sq m) such as Chicago, Cité des Sciences et de l'Industrie (Paris) or the Ontario Science Centre, have millions of visitors annually. Such institutions receive over half of the 50-plus million (1986, number growing) people who visit science centres annually (ASTC 1990). Approximately half the centres are small, under 250 sq m, and this most typical type of centre receives just 5% of all visitors (ASTC 1990; Grinell & St.John 1990). The medium-size centres, between these two, aim to be "full-service" centres on a moderate scale with permanent exhibitions, educational programmes, films, public lectures, family happenings, temporary exhibitions, etc. (Heureka 1990).

Danilov (1982, 48-50) drew scenarios for future development, most of which seem to have been correct prognoses: the number of centres is still rapidly increasing; there will be only a few mega centres; the main trend is for several medium or small-size centres to form some kind of network; the main developments will happen in the countries where science centres have not existed before; and, in the long term, the developing countries will have more and more centres.

Although Grinell (1991, 15-16) predicts that centres will become more and more alike, local centres around the world are also creating new exhibits, expanding the concept of hands-on science beyond basic physics, and applying the principle and techniques of interactivity to exhibitions on a great variety of themes. These trends can be seen at the turn of 1990s in Asia, Australia and Europe, especially in Scandinavia and Britain (Quin 1991, 1-7).

- an interdisciplinary approach to science. Another important factor is the development of active collaborative relationships between science centres and other institutions such as research centres, the formal educational system, cultural institutes, art organisations and the mass media.

2.7. The Information Society:
The European and Asian Era 1985 onwards

In the 1980s the development of new science centres took place mainly in Europe, in Japan and in some Asian countries, while the "old" centres expanded their functions.

The Cité des Sciences et de l'Industrie located at la Villette in Paris is a huge complex developed in a building originally designed as a modern industrial slaughterhouse. Strong emphasis is placed on a modern technology, and the number of exhibits relating to modern production processes is remarkably high (Cité des Sciences et de l'Industrie 1987).

Cité des Sciences et Industrie is one part of a development plan consisting of a science centre, OMNIMAX-film theatre, modern library, concert hall, commercial exhibition hall, sports and other leisure activities. The science and technology centre alone is so large (70 000 m2) that a single floor could contain several small or medium science centres. The proportion of exhibits involving audiovisual equipment is very high and it was the first centre to start using interactive laserdiscs on a large scale in its exhibitions. The spread in France of the PC-computer exerted a strong influence, even beyond the exhibitions: an essential part of the Cité is its multi-media library. Nevertheless, some 'classic' science centre

proportion of exhibits involving audiovisual equipment is very high and it was the first centre to start using interactive laserdiscs on a large scale in its exhibitions. The spread in France of the PC-computer exerted a strong influence, even beyond the exhibitions: an essential part of the Cité is its multi-media library. Nevertheless, some 'classic' science centre exhibits can also be found, for example in the Cité des Enfants (department for children only) and in the main exhibit halls. The Cité invests heavily in temporary exhibitions.

Other areas where new science centres developed rapidly in the late 1980s were Great Britain, and especially the Nordic Countries (NSCF 1990, 1-25):

The first Nordic science centre, **Teknorama**, was opened as part of the Technical Museum of Stockholm in 1985. The exhibition consists of the classic, Exploratorium Cookbook type of hands-on models. The exhibition is about 500 m2 in size (Sandqvist 1982, 1988).

Teknikens Hus (House of Technology) was opened in Luleå, Sweden, in spring 1988. The centre focuses on the natural resources and sources of livelihood in Northern Sweden, complemented by some classic hands-on models. When opened, the Teknikens Hus was the biggest science centre in Sweden. Numerous small centres also exist: Kunskapstivoli in Malmö, Fenomenmagasinet in Linköping, Tom Tits Experiment in Södertälje, Fenomenalen in Gotland, Framtidsmuset in Borlänge and Energicentrum in Umeå.

The first Danish science centre **Eksperimentarium** was opened in Copenhagen in January 1991. This project, financed by the city, state and private companies, is housed in an old, one-kilometre long bottling hall. Eksperimentarium has received very favourable reviews both from its visitors and from science-centre experts all over the world (Quin 1991, 3). The centre combines physical sciences, technology and a well-planned department of human biology in its exhibition. In Denmark some museums are developing their traditional exhibitions in new interactive ways. Two successful examples of this process are **Elmuseet** in Bjerringbro in Jylland, and **Nordsjömuseet** in Hirtshals.

2.8. Heureka - The Finnish Science Centre

The tradition of museums in Finland is strong at local, county and national level: the number of museums (over 5000) per capita is the highest in the world (Hudson 1988, 3-7). Over eight hundred museums are listed by the Finnish Museums Association (Suomen Museoliitto): Most are museums of cultural history (563); special museums are the second most common type (155), followed by art museums (55), provincial - often cultural history - museums (20), and finally natural history museums (17). (Suomen Museot - Finland's Museums 1990.)

The popularisation of science is not an easy task (Niiniluoto 1989; Leikola 1989). However, it has been strengthened in Finland during the last decade (Ketonen 1989). The clearest evidence for this is the publication of the popular science magazine, Tiede 2000. Science books are selling in increasing numbers, and scientific television programs are

attracting growing audiences. The number of science pages in the newspapers has also increased, for example in the national daily Helsingin Sanomat. The history of popularising science in Finland is described by Leikola (1968), and he notes a few books from the 19th century.

Heureka - The Finnnish Science Centre is an exhibition centre, and not only for science and tehcnology. The word "tiede" ('science') has different meanings in Finnish and English. "Tiede" does not only cover the natural physical sciences and technology, but also includes the full spectrum of academic subjects: social science, the humanities, psychology, history, linguistics, etc. The word "tiede" is thus very close in meaning to the German "wissenschaft", or the Swedish "vetenskap". "Science" comes from the original Latin "scientia", meaning "knowledge". This knowledge was not restricted to a few topics or phenomena of life (Suomalainen tiedekeskus 1985).

One of Heureka's main missions is to cover the whole academic field. This will be achieved by developing an interdisciplinary approach (Miettinen 1984). The idea is not to show exhibitions of medicine, but to adopt a scientific approach to topics from biology, medical science, chemistry, psychology and sociology - some or all of the (Heureka 1987; Tyystjärvi 1989).

The main exhibition is 2100 sq m; the hall for temporary exhibitions 700 sq m. There is also a hemispheric film theatre and planetarium, the Verne Theatre (Sutela & Jännes 1988), an auditorium and three classrooms.

The building is located in Tikkurila, the City of Vantaa in the Greater-Helsinki area. Heureka is the first large-scale science centre in Finland.

The science centre project started with a temporary exhihition: Physics-82. The university community responded very positively to the concept of a science centre, and the idea spread rapidly to encompass the state, the university and research communities, and Finnish industry. The Science Centre Foundation was established, and the planning and fund raising stages could then proceed. The founding costs were shared by the City of Vantaa, the Government and industry (Heureka 1987).

The main exhibition consists of about 150 exhibits, with which visitors can interact in a hands-on manner, helped as necessary by trained guides. There are four broad themes to explore: the Universe, Life, Human Society and Production. Since 1989, there have already been seven temporary exhibitions: Sound and Voice, Lucy: The Human Story, The Iron Age, Structures, Artificial Intelligence, Dinosaurs, Balance?: Environmental Exhibition, and Finland-75: historical exhibition.

The formal opening took place on April 27th 1989. During the first year over 500 000 people visited Heureka. This included the 90 000 school children visiting the centre in groups. By the end of 1992, 1 300 000 visitors had been to Heureka.

For schools, guided visits are offered either in the form of an overview of the exhibits, or on one of four themes: Water, Human Biology, Language, Time and Universe. The formal education system collaborates with Heureka in planning school visits to the science centre.

Research related to learning in science exhibitions has been conducted throughout the Heureka project. Details may be found in the paper "Heureka - Planning of Insightful Learning" (Hautamäki & Salmi 1987).

There are five other science centres in Finland: Tietomaa (2000 sq m) in Oulu was the first, opened in 1988. It has hands-on models and many computer-based exhibits. Kammi (600 sq m) in Jyväskylä, specialises in energy and environmental topics, with modern exhibit design. Mini-Finland in Ähtäri exhibits industrial production in Finland, and has a zoo and other activities for families. The Museum of Technology in Helsinki consists of a traditional museum collection of Finnish technology and industry. Folkhälsans Health Promotion Centre is a mini science centre (500 sq m), visited by appointment only, and intended mainly for school groups (NSCF 1990).

2.9. Science Centre Education

"I hear - and forget. I see - and remember. I do - and understand." This Chinese proverb is often cited as the educational thesis of science centres. It has certain fudamentally valid ideas. But the educational role of science centres has not been deeply analysed - it has been taken more or less as self-evident. However, some classical educational theories can be detected in the principles underlying science centre education, although few educators in these institutions have been explicit in their approach. They have relied, rather, on the practical and common-sense application of loosely formulated pedagogy.

John Dewey is best known for his thesis "learning by doing". The familiarity of this quote shows that he has been able to crystallize something very central related to learning. Dewey's theory is often over-simplified, too. Learning by doing is not a question of isolated tricks, but is always part of a complete, planned learning and teaching process (Dewey 1938).

Dewey critised the teaching tradition, in which the pupils' role was to listen - and listening means passivity. As an alternative to this, he demanded that schools have workshops, laboratories, materials and tools with which the pupils could construct, create and actively enquire (Dewey 1938; Bowen & Hobson 1988, 162-214).

Dewey emphasised that there should be sufficient opportunities to satisfy the child's natural need to act and investigate in all educational situations. Teaching must be based on the fact that children collect their own impressions from experience and then arrange their observations according to new, more general concepts.

Experience is one of the key elements in Dewey's theory. It is sometimes even more essential than knowledge, which can be accompanied by very superficial features learned by rote (Dewey 1938, 33-50).

Dewey's ideas and pedagogical programmes, applied in his own school, had great influence on the whole school system in the USA. During the same period, Kilpatrick's theories were developed to support the teaching of practical technical skills. It is clear that the worldwide spread of these

pedagogical theories also had great influence on the birth of science centre education in the 1930s, and more recently.

The central concepts of science centre education were introduced in chapter 2.5. Oppenheimer's criticism (1968; see ch. 2.5.) of the "passive pedagogy" of science education derives implicitly from Dewey's ideas. The same trend can be seen in contemporary developments in science centre pedagogy: The famous hands-on principle articulated by Oppenheimer is one corner-stone of the principle of interactivity in modern science centres (Quin 1991; Falk & Dierking 1992; see ch. 2.8.). What Dewey and modern science centre pedagogy share is the accent on free will and the learner's own activity, stimulated but not forced.

Olkinuora (1990, 27) has shown the advantages of learning through problem-solving projects, in which the students discover by means of their own research. But he also quotes Ausubel's criticism concerning the one-sidedness of discovery learning as advocated by (early) Bruner: It is a waste of time to learn and to teach all the facts and skills of a cultural tradition in that way.

Science centres and science education

The field of science education is broad and complex consisting not only of the formal education system from kindergarten to highest research level, but also of the informal influences of modern society, technology and culture (cf. e.g. "World trends in science and technology education 1985"; Frey 1989). The problems and opportunities of science education are discussed here only in their relation to science centres.

Piaget's theories of cognitive development (Piaget 1976, 16-21) have affected all education. Hautamäki, J. (1990, 46; see also Jackobson & Kannisto 1990) describes two traditions, one from Piaget and one from Ausubel, in the development of science education. He notes that both these science education traditions ignore the role of the teacher or tutor. In this study, therefore, it is essential to deal also with the ideas of Vygotsky (1982). The principle of action is central to his theories. The learner's activity is also the key element in science centre pedagogy (Hautamäki & Salmi 1987). The affective side of learning, especially motivation, is also emphasized (Wellington 1989; see 3.6.).

A recent direction in educational research, which combines the science education traditions of Ausubel and Piaget, deals especially with "naïve notions" or "false pre-conceptions" (Sere 1986; Mariani & Ogborn 1990; Rowell, Dawson & Lyndon 1990). Similar studies have also been conducted in the science centre context (Borun 1989, Javlekar 1989).

Hautamäki has analysed science education and its relation to science-centre education in several contexts (Hautamäki, J. 1990, 1989, 1988, 1987a, 1987b; Hautamäki & Kurenniemi 1988; Hautamäki & Salmi 1988).

Hautamäki, J. (1990) also raises the question of pupils' ability to solve problems to which they have not already been taught the correct method. This is an essential question in science centre settings, where the problem is often new to pupils, and the method of collecting data is itself totally different from that in the school situation (Hein, H. 1987, 59-61).

But there are problems involved in combining the principles of child-centered education ('progressive pedagogy') with a content that has been chosen by adults. Hytönen (1992) notes a certain antagonism, and argues especially against uncritical over emphasis on so called 'independent working and investigating by a child'. There are several examples where a child is able to conduct complicated manual or practical operations with a computer or with a simple mechanical model, but does not understand the phenomenon she is so perfectly demonstrating.

Although this criticism (ibid.) is mainly focused on formal education and certain pedagogical projects, it is also relevant to science centre education. Similarly, the surperficial application of Dewey should be critisised: learning by doing, with no connection between manual experience and cognitive content will lead to educational disaster. However, a science centre is an ideal educational environment, because it fulfils all the preconditions that Ausubel et al. (1978) include in "meaningful learning" (cf. Falk & Dierking 1992).

The use, in school, of pre-visit materials increases both the cognitive and affective results of a visit to an exhibition (Melton 1935; Salmi 1984). The guides and teachers play an essential tutorial role during the science centre visit (Grinder & McCoy 1989; Quin 1990). The structure and form of the pre-visit tasks are important. The teacher's instruction, acting as a link between guide and task, is also important for pupils (Vahtera 1991). The nature of the task is significant: the work-sheets and tasks must be prepared in close relation to the exhibition content and the demands it makes on the visitors (McManus 1985). Developmental level is a key factor in planning the tasks (Kurronen 1991). There is evidence that

carefully-prepared tasks can develop pupils' scientific thinking (Hautamäki, J. 1990, 1991).

One non-trivial problem in the discussion of science education is related to the meaning of the word "science". In English, science generally means the natural and physical sciences and is often limited to physics, chemistry and biology. However, in German, Swedish or Finnish, for example, the words "wissenschaft", "vetenskap" and "tiede" also include the humanities, history, psychology, social science and linguistics. So the term science education - "tiedeopetus" in Finnish - can be defined in two ways and we must be clear which definition is implied (Olkinuora 1990, 21): 1. teaching that is based on the academic research process, i.e. problem, hypothesis, experiment, research, result, analysis, conclusion. 2. the teaching of certain school subjects, natural and physical scientific facts and concepts.

The different definitions of the term "tiedeopetus" (science education) have important implications. One cultural aspect in Finland is that a good all-around education ("yleissivistys") used to consist of knowledge of history and other world cultures, the ability to speak different languages, and interest in art and music; but a basic knowledge of the sciences was not necessarily included. This has been changing gradually, and received impetus as a result of the Chernobyl accident. For example, the mass media were unable to give reliable information about the crisis; for the general public, the event was even more difficult to understand. Chernobyl, as well as many environmental problems and issues of our information society, caused decision-makers to wake up to the importance of science education and scientific understanding for everyone, not only

the experts (Numminen 1984, 4-7). The rapid development of PC-computers and other new 'every-day' technologies fueled the development of science centres in the 1980s, in the same way that the Sputnik-phenomenon provided the impetus for science education reform, and the creation of modern science centres, in the U.S.A. two decades earlier.

In the UK, the teaching of science is seen as a practical activity. The central role of practical work, with hands-on, experiments in the laboratory, has been enshrined in guidelines for teachers troughout the 20th century (Woolnough 1991, 3). However, in the classroom, the balance between practical work and theoretical study has shifted several times. With the introduction of Nuffield science in the 1960s, laboratory experiments became the norm in all schools. The relation between conceptual understanding and practical work is critical to effective teaching, and the role of intrinsic motivation should not be underestimated (Gott & Mashiter 1991, 61-63; Woolnough 1991, 183).

Science centres are institutions of informal science education (see ch. 1). The pedagogy of science centres must be planned for a very heterogeneous public.

Science centres have generally developed educational programmes to enhance their appeal to visitors. However, another role for science centres has grown out of this work: science centres have turned out to be appropriate places for educational experiment and pedagogical development. This role of the science centre as a laboratory for education has been discussed (Oppenheimer 1976; Numminen 1984; Salmi 1986, 1989; Feher 1990). The idea of transferring pedagogical practice from

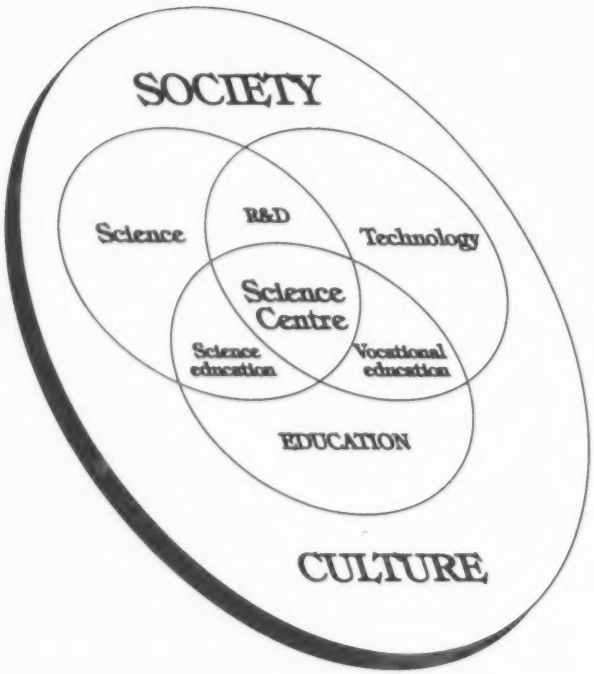
science centres to schools has also been proposed (Olkinuora 1990). But although informal science centre education can catalyse change in formal school education, the two are not comparable (Takala 1984, 28-29). Therefore, a science centre should concentrate on education that is interdisciplinary, displays the results of recent research, and uses special equipment not available in schools (Malinen 1984, 22).

A new way of defining the position of a science centre in its relation to science, technology and education is presented in the figure 2.A. (Hautamäki, J. 1987, 10-11): Science education is at the point where science and education overlap. Science and technology combine in the area of research & development (R&D), where academic research is used to develop industrial production methods, and so on. Vocational education is at the intersection of technology and education.

A science centre is located, in the figure 2.A., where science, technology and education all meet. According to this description, a science centre combines the features of these three.

One essential question arises from the definition of the word 'science'. As discussed earlier in this chapter, if the word covers only the natural & physical sciences, many features are excluded. Concerning the diagrammatic description above, there are two options: 1. 'Science' must be defined in its widest meaning, to cover all research occurring at university level. 2. The ven diagram must be put inside a circle that also contains society and culture, as has been done.

Figure 2.A. Science, technology, education and a science centre in relation to society and culture.



The links to society and culture place science and education in context. The figure above emphasises the pivotal position of a science centre. Pivotal in the sense of this study: an equivalent position in world affairs is not to be inferred.

2.10. Research on Visitor Behaviour and Learning in Science Centres

There was very little early research into learning, teaching and education in science centres, and few data are reliable and valid (Falk 1982; Falk & Dierking 1992). However, research into science centres increased rapidly during the late 1980s (cf. Visitor Studies: Theory, Research, and Practice 1988, 1989; Sharing Science 1989; ASTC Reports; Understanding Science 1991; Journal of Museum Education: Roundtable Reports 1983-1990; etc.).

Equally, before the 1970s few approaches to the large field of science museum education were made. Some of the classical studies have, in part, been recently reprinted (1988, ed. Robinson) Experimental Studies of the Education of Children in a Museum of Science by Melton, Feldman & Mason from 1935.

But new methods are also needed. Observation methods, for example, are often planned for school, classroom or laboratory situations (Falk 1976; see also Evertson & Green 1986). Some approaches have been made (Lucas, McManus & Thomas 1986, Borun 1989). In the field of visitor studies, in particular, there has been much progress (ILVS 1988; Visitor Studies 1989). The background to visitor behaviour studies owes much to Gallup and market research methods.

Some researchers are strongly of the opinion that informal education should not be studied using classical quantitative methods alone (Diamond 1982). This opinion is supported by the latest trends in educational

science (Erickson 1986). At present however, all research into informal education must be conducted very carefully: the imprecise data and reports based on anecdotal evidence are already more than sufficient (Shettel 1976; Balling & Falk 1981; Falk & Dierking 1992).

The four main trends in science centre research can be classified as follows (1-4):

1. Demographic surveys

The research most often carried out in science centres, museums and exhibitions concerns the visitors: Who are they, where from and how did they travel, how old are they, what is their social background, etc. (for example: Heady 1984; Suomen museoliiton julkaisuja 29 Finnish Museum Association 1984). All institutes need this kind of statistical information.

Population censuses, demographic surveys and market research are the origins of this type of visitor analysis, and the results are required for many different purposes: for marketing, policy making, fund raising, for economical reasons and for developing the functions the institution (see Loomis 1988, 12-24; Shettel 1976, 51-57; 1988, 25-30; 1989, 41-42; Patterson & Bitgood 1988, 44-45; Audience Research Consortium of Toronto 1989; Kelsey 1989, 141-143; Hood 1989, 32-41).

Visitor surveys often produce results that appear obvious. However, people working in science centres soon become blind to their own visitors and exhibitions: Are they male or female, why do they come - and come again, and how long is their visit. Many self-evident "facts" are also

shown to be questionable. Another weakness of demographic surveys is the "myth of an average visitor" (Rohmeder 1977, 24-25). These questions are closely related to the issue of the democracy of an exhibition: is it meant "for everybody" or "for somebody" (Adolfsson 1987, 189-202).

2. Technical reports

Testing, making mock-ups and prototypes is a typical way of planning a science exhibition. Few of these planning processes are reported. Normally it is a matter of common-sense knowledge and experience for the technicians and designers.

However, some interesting cases have been reported. Also, science-centre conferences now frequently include a workshop discussion about exhibit building. Some books have been published. Good examples are Exploratorium Cookbook I & II (1976), Good show! A Practical Guide for Temporary Exhibitions (Witteborg 1981) and Cogs, Cranks & Crates (Levy 1989), which give information concerning materials, text labels, and lights, etc. for travelling exhibitions to be built and re-built again.

Helokumpu (1987, 1-38) gives a detailed report of the planning and building of one exhibit unit: The periodical system of elements - a car split in half. Nieminen (1988, 1-57) illustrates various aspects of exhibit development: the purpose of his study was to investigate the use of electronics in interactive exhibits. He chose four case studies and, by analysing the planning and building process, was able to give general

recommendations and specific examples of ways to combine electronics, computers and mechanical parts.

3. Front-end evaluation

Front-end analysis describes the evaluation process that is carried out before plans are implemented (Miles 1982, 134). The term front-end analysis/evaluation began to be used in the 1980s (Walker 1988, 139-140), and is directly related to cognitive learning theory and educational pratice (Shettel 1992).

Such studies resemble technical reports, but the main difference is that human beings, as visitors and exhibit users, are included. Front-end evaluation is conducted before exhibit design. Actually it is part of the concept- design stage, when the behaviour, attitudes and knowledge of the potential visitors all contribute to the planning process (Walker 1988, 139-144; Ades & Fishman 1992, 299-302).

4. Formative evaluation and summative evaluation

Formative evaluation ("developmental evaluation") is carried out during the planning of an exhibition, but may also be applied to the development of teaching materials for the visit, to improving the methods of guides, and to making some (inexpensive) changes to the existing exhibition. Formative evaluation is not formal scientific research: the aim is to provide practical knowledge for planners and designers (Screven1988, 73-82).

Summative evaluation ("post-design evaluation") gives information about the completed exhibition. Results from a summative evaluation study are used mainly in the planning of the next exhibition (Screven 1988, 73-82; Walker 1988, 139).

Labels are the subject of many studies. The publishing (typography, lay-out, etc.) and technical problems are not inconsiderable (Bitgood 1987, Finlay & Woehr 1986, Miles & al. 1982).

Similarities and general rules can be observed in visitors' behaviour worldwide, but clear differences between cultures have also been found for example in the way visitors notice, scan and read the labels (Bitgood, Pierce & Patterson 1986; McManus 1987; Hautamäki & Salmi 1987).

2.11. Classification Model for Science Centre Research

Miles & al. (1982) wrote a widely-read theoretical and practical book The Design of Educational Exhibits. He gives useful examples of the planning of different kinds of exhibitions, but also goes far beyond simple practicalities and discusses the design theory underlying exhibition planning.

Miles (1982, 6-9) describes the two traditions of exhibition planning:

A. The space orientated tradition was created by Walter Grophius in 1930s. He used space in a radically new way. The exhibition's exterior itself gave a message by creating a mood. Visitors should be able to move freely and the theme of the exhibition should flow in the same way.

He also started to use new exhibits of pictures and text produced by modern printing techniques. These techniques were revolutionary compared with the rigid traditions of museum and other exhibitions at the time.

B. The content orientated tradition focuses not on space but on communication and the visitors' need to understand the message of the exhibition. This tradition was initiated by Otto Neurath, while renewing the Social and Economical Museum in Vienna in the 1930s. He also used the term 'humanisation' instead of 'popularisation' of knowledge. This definition sums up his emancipatory goal: that knowledge should be understood by people, instead of ruling them. He also developed a new method (Isotype = International System Of Typographic Picture Education) to illustrate statistics, figures and tables.

These two traditions conflict with each other. Advice in the modern exhibit-design guide books attempts to combine them. Nevertheless, there are far too many examples of simple phenomena, demonstrated in expensive and ineffective ways, to be seen in science centres. Also, many exhibitions are planned and constructed without thinking of the message to be communicated, or considering the alternatives to building exhibits. Miles (1982, 8) concludes that in an ideal planning and design situation, space and contents should be taken as the joint starting points.

This is nothing new: the discussion of the balance between form and content is familiar from theories of teaching and art. Content is the basis and should not be underestimated (McManus 1986). However, form is the medium of the exhibition and has its own value.

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An exhibition is a visual entity, even an independent piece of art. People learn from the exhibition - consciously or unconsciously - as a result of the planners' work, or despite it (Shettel 1968; Quin 1989).

Hein, H. (1990, 23-44) describes the role of planning and design in creating a science centre by the words "design and serendipity meet" - The Exploratorium is the science centre she takes as an example.

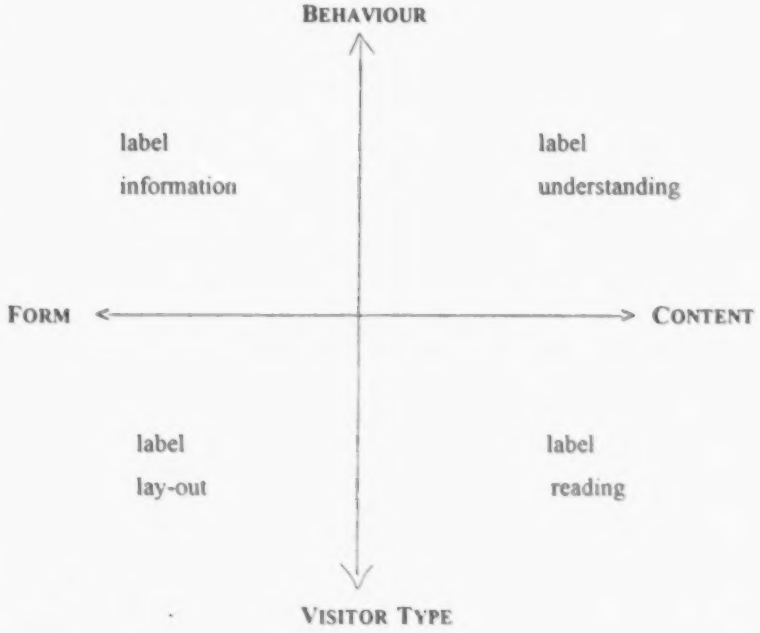
The careful planning and testing of an exhibition is important, but since the process involves many compromises there is an in-built danger, which Adolfsson (1987, 198-199) calls "the double censoring effect": an exhibition integrates the opinions of its planners, and often incorporates the anticipated opinions of average visitors. This kind of self-censoring produces uncritical exhibitions, and clearly conflicts with the critical approach of academic research, which museums and science centres should encourage.

From the two traditions of planning exhibitions, the dimension FORM >< CONTENT is applied in the following model to classify the different kinds of research.

Falk & Dierking (1992) have created "The Interactive Experience Model" as a theoretical tool for describing an exhibition visit. Their model has three dimensions - social context, personal context and physical context - forming the total interactive experience of an exhibition.

VISITOR TYPE >< VISITOR BEHAVIOUR is the other dimension in the model describing science centre research (see Figure 2.B.).

Figure 2.B. Classification of science centre research by the form-content and behaviour-visitor model.



The figure above describes the different approaches of science exhibition studies. Only one example is analysed: labels are the classical subject of studies. However, they can be studied from several points of view. Technical reports deal with features of lay-out and design, for example the fonts of the letters or process of producing labels. Label reading time is a common topic of visitor surveys. Studies on the information-content-of labels and its effect on exhibition behaviour helps a planner to arrange

exhibit units in a meaningful way. Label understanding is a typical subject of formative evaluation: is the message understood.

This example of different kinds of label studies, also shows the most typical research goals of technical reports, visitor surveys, front-end evaluation and formative evaluation.

2.12. Pre-lessons in Science Centre Learning

Technical reports, visitor surveys and front-end analyses have affected the development of programmes for school visits, although the major influence on exhibits has been achieved by formative evaluation. The area of educational studies is most often in the behaviour-content area (see figure 2.B.).

The results of some educational studies related to the major topic of the original research presented in this study are introduced below.
Pre-visit lessons have a positive effect on the learning that results from school visits to museums, zoos, aquaria, science centres, and from biological field trips. This is due to the fact that pupils 'learn' the same concept or information twice, under different conditions, through different media and with different people - the teacher and the guide.

Pre-visit materials are used in most of the science centres which have established programmes of school visits. The materials range from worksheets, experiments and videos to general information concerning the visits (Heureka 1991a; La Villette 1987). Pupils receive basic information on the topic of the visit, and they know where they are going. Just as

important, is the fact that a teacher who uses pre-visit materials is one who plans the whole visit very thoroughly.

The effect of pre-visit lessons has been studied in many science centres and museums. Experimental Studies of the Education of Children in a Museum of Science is one of the first studies of science-museum education, made in 1936 by Melton, Feldman & Mason and edited by Robinson. As part of this early research, the effect of different kinds of pre-visit lessons was studied carefully, and it was found that: silent-reading lessons have a positive effect; the use of visual materials increases the effect; and the shorter the gap between lesson and visit, the more effective it is (Melton & al. 1936, 24-32).

The same results have been repeated, confirmed, and also extended in several studies (e.g. Davis & Kimche 1976, Danilov 1982, Gennaro 1981, Koran & Baker 1978).

In most science centres, pre-visit materials for schools are produced. To complete the educational visit, there should also be post-visit tasks and materials that reinforce and extend the theme of the visit (Salmi 1984, 17).

More emphasis has recently been given to the role of pre-visits by teachers, and to materials giving specific teacher guidance (Mark St. John 1990, Salmi 1984, 21; Heureka 1991a).

2.13. Settings and Novelty as External Contexts of Learning

Evidence from educational science indicates that novelty is one of the principal factors in encouraging learning (Berlyne 1960, Bruner 1986). Play, exploration and curiosity are all positive factors enhancing the child's cognitive development (Görlitz 1987, Wohlwill 1987). The novelty can arise within or outside the learning context, i.e. from the learning of a new subject or from a new setting.

According to Taba, Levine & Elzey (1964, 97-99), a pupil must organise the learning situation and its key factors every time she encounters a new kind of learning situation. Only after this process can effective learning take place. This is particularly true of new external settings: the dominant features of the new place must be recognised and accepted. This theory is confirmed by Taba's research (1966) into children's thinking and learning strategies.

Piaget's theory of assimilation-accomodation-equilibrium describes the development of a child's thinking, but also clearly describes the influence of settings on learning. (Piaget 1976). Basically, the child is trying to find the equilibrium between her environment and herself.

Does the setting an sich influence learning? Of course the environment, colours, design, etc. exert an influence - ask any architect or artist! The theory and practice of exhibition design and its effects have been studied, for example, by Otto Neurath in the 1930s and lately by Roger Miles (1982) and Wittenborg (1981).

If the setting is too strange it can even arouse fear; on the other hand, a too familiar setting can be boring. Both cases may prevent learning. The shock of a new setting can be addressed by the so-called "sniff around corners" method (Balling & Falk 1981), which has been applied in Heureka's science courses by means of a photography orientation game (Salmi, T. 1990, 5-7).

The major conclusions of this study are that the atmosphere of an informal setting stimulates learning through observation, but that concepts are more easily assimilated in familiar settings (Falk & Balling 1981, 235-240). It has also been found that, the more unfamiliar the setting, the more pupils try to get help from their peers. They may be seeking help with a learning/understanding task but if, because of the novelty of the setting, even the peer group can not help, the result is an increase in disturbance and non-goal related behaviour (Falk & Balling 1981b, 306-308).

The influence of physical settings on learning has been discussed in many studies (Martin, Falk & Balling, 1977, 1981; Balling & Falk 1981; Miles & al. 1982; Falk & Dierking 1992). The results can be summarised as follows: 1. Pupils do learn cognitive facts in out-of-school situations. 2. The setting has a major effect on learning. 3. The novelty of the setting is the most important factor in learning in out-of-school settings. 4. The "novices" learn simple facts but do not succeed as well as the "repeaters" in concept-learning tests. 5. Age, sex, social background, etc. are not significant factors.

Motivation in science centre learning is discussed in chapter 3.6.

2.14. Summary Of Chapter 2

The roots of science museums can be traced to the ideas of such respected scientists as Bacon, Descartes and Franklin. The first collections of fine scientific models were made by wealthy aristocrats. The great world exhibitions also influenced the creation of major science museums at the turn of the century.

The social, cultural and technical development of society cannot be neglected. Industrialisation brought the need for a more educated workforce. Technology and science played an increasing role in the lives of ordinary people, and came to occupy a place beside religion, the state, art and history in the socialisation process.

Other characteristics of science museums established from 1850 to 1940 are: financial support for private collections to be made publicly accesible; a perceived need for enhanced science education; museum directors with strong characters and personal support at a high level in society.

Science centres are firmly planted in the soil of the society that nurtured and continues to support them. The impact of developments in society, science and technology is crucial to the process of starting and developing science centres. If these institutions cannot respond to social change, and renew themselves, they very easily loose their ideological credibility and financial support (Hudson 1977, 7; 1988, 1-3; 172-73).

In the USA, the background to the expansion of modern science centres was the Sputnik phenomenon. No direct link can be documented, but the

crisis in national confidence that resulted from Sputnik had a knock-on effect on all education in the USA (Bruner 1960, Friedman 1989, Hein, H. 1990).

Science education is not only a question of advancing technology or of demands for a scientifically qualified workforce. It is also a question of social goals as Coombs summarizes: "The aim is not solely to produce more scientists and technologists; it is also to produce a new generation of citizens who are scientifically literate and thus better prepared to function in a world that is increasingly influenced by science and technology" (Coombs 1985, 246).

In pursuing this aim, new forms of education are actively sought. Informal, out-of-school programmmes are taken advantage of and used. Science centres co-operate more frequently with the formal education institutions (Hautamäki, J. 1989, 1-3).

The same trend can be recognised in current developments. The growth of science centres in the 1980s, especially in Europe, is closely related to the development of the information society. Communicating science to the public through different media is not only a means of attaining sufficient financial support for scientific research and academic education but also a process of giving citizens their basic democratic rights in relation to science information (Persson 1992; Wakamatsu 1992; Quin 1993). The future worldwide trend for the 1990s appears to be a broadening of the subject range of science centres and an increasingly interdisciplinary approach to exhibition themes.

3. MOTIVATION

The origin of the word "motivation" is in the Latin word "motivus", mobile. The first recorded use of the word "motivation" in English is from 1873, when it appeared in Contemporary Review XXI in connection with Schopenhauer (The Oxford English Dictionary, OED, 1971). The OED defines it as "The action of the verb MOTIVE", but the contemporary use of the term in psychology and sociology is given in A Supplement to the OED, volume II:

"The conscious or unconscious stimulus for action towards a desired goal provided by psychological or social factors; that which gives purpose or direction to behaviour."

The first recorded use of the word in this sense is from 1904 in Psychol. Rev. Monogr. Suppl. v. II as a heading: "The egoist and the social in motivation".

Motivation is a word that is used in very many contexts. It is originally a psychological term, but is nowadays used also in every-day language.

Motivation is used in quasi-psychological literature, or when people analyse reasons for frustration with their work or studies. The term is also used in sports language: a sportsman or a team suffers from lack of motivation. In these every-day situations motivation is a large umbrella term for describing reasons to do or not to do something. It is also an analogy for "having a goal" or "having a mission".

Motivation is, unfortunately, also used very loosely in many studies in psychology and educational science. Sometimes the researchers do not even define the term or give its theoretical background.

According to the naive learning theories, learning occurs when the learner is motivated, i.e. when she wants to learn (Julkunen 1989, 35). DeCharms (1987,1-2) integrated the definitions of motivation in different human sciences and showed how psychologists, physiologists, sociologists, learning theorists, cognitive theorists and social psychologists all emphasise very different factors of motivation and even give opposite meanings for the term so that "the burden of meaning is too heavy for the beast (ibid., 1)". However, there is no need to settle for these inexact definitions of motivation, because exact versions can be found - and should be demanded.

3.1. Theories of Motivation

It is not easy to define the term motivation. Keller (1981, 22-23) found over fifteen theoretically different definitions. In the late 1960s, when achievement motivation theories were still fairly unified, it was nevertheless possible to list over twenty theories (Madsen 1968). Comparing the numerous definitions is not very fruitful, but the structural differences between the theories behind them give more information.

The field of motivation research is very complex and heterogeneous. In Finland, many analyses have been made in the context of motivation studies and the main trends in the research are being established (cf. Leino 1972; Vikainen 1974; Koivumäki 1979, 1980; Vepsäläinen 1980; Engeström 1984; Peltonen & Ruohotie 1987; Julkunen 1989; Mustila 1990).

Different motivation theories have historically and theoretically different backgrounds. In some central respects, the theories are also in crucial conflict with one another. The main disagreement arises from the research approach: whether from biology, psychology or sociology.

These approaches can be seen in many classifications of motivation studies. Korman (1974, 2) shows three main categories: 1. Cognitive theories. 2. Instinct theories arising from physiology. 3. Humanistic theories.

Vepsäläinen, based on the work of Anzyferova (1976), classifies motivation theories in four categories: 1. Homeostasis theories. 2. Personality theories. 3. Achievement motivation theories. 4. Inner conflict theories.

There are certain similarities between these two classifications: Personality theories (Vepsäläinen) resemble humanistic theories (Korman) to a great extent and classical theorists like Maslow and Rogers are mentioned in both. Similar links can be observed between cognitive theories and achievement theories; Atkinson and McClelland are mentioned in this connection. Korman (1974) offers cognitive theory as an overall concept for achievement theory. The link between homeostasis theories and instinct theories is also obvious, and neo-behavioralists are mentioned in both connections. It is clearly a question of unwillingness to use the same terms, which relates to the different scientific philosophies and different educational images behind the different theories.

The classification of motivation theories by Vepsäläinen (1980):

1. Homeostasis theory defines motivation as a process of activity during which excitement builds up and is released. Excitement grows inside a person for several reasons, and when it becomes unpleasant, she tries to release it. The main reason for this behaviour is the imbalance between a person and her environment, and the behaviour is the way of restoring equilibrium. Therefore motivation is defined in negative terms, i.e. as a process of avoiding negative feelings.

This theory originates in psychoanalytic theory. Freudian research and theories explain the behaviour of a person on the basis of instincts. Neo-behaviorist theories explain motivation in the same way, but they emphasise physiological factors.

2. The growth of personality theory is opposed to homeostasis theory. According to this theory, a person constantly resists the state of equilibrium and seeks excitement in order to fulfil herself. She tries to get into situations which offer new challenges and opportunities. Motivation is basically this hunger for new experiences. In addition, motivation helps a person to learn new things. She tries to control situations in order to keep the level of excitement high enough and yet to prevent it from causing fear. During the course of her life, a person also reaches new levels and finds new sources of motivation according to her temporary needs and her life situation.

This kind of definition of motivation is typical of theories concerning life's needs and goals. Maslow, Allport and Rogers are usually mentioned as the leading theorists of the field.

3. Achievement motivation theory sees achievement an sich as motivation. If a person is assured of the probability of gaining positive results from an activity, she will start the process. The activity and its result give her satisfaction.

Achievement motivation theory was formulated by Atkinson (cf. 1957; 1964; & Al. 1974) and McClelland (cf. 1951; 1961; 1971; 1985). This view of motivation has gained strength in the last four decades and is at the moment the most popular view in the western world.

4. The conflict theory defines motivation as starting from an intrinsic conflict. A person notices that she lacks information or skills, and therefore finds herself in an intrinsic conflict between the existing situation and her needs. Motivation is defined as the trigger for the activity that will solve this conflict. The roles of society and the subject's own activity are essential to this theory.

The main figure representing this theory is Rosenfeld (1973) with influences from Marxist theories.

Vepsäläinen's classification (1980) of the four schools of motivation theory introduced above is of historical interest, and though it is still useful it must be qualified: both the homeostasis theory and the growth of personality

theory are signficant for having given scientific respectability to motivation studies (cf. Weiner 1990).

Motivation research became important to educational science after the so called "Hull-Tolman" debate: Tolman's argument was that there can be learning without reward or drive reduction. As summarised by Weiner (1990), Tolman's idea was important for the formulation of cognitive theory by Kurt Lewin and the later development of achievement motivation theory by John Atkinson.

In practice, however, motivation models may combine elements from several overlapping theories: for example Jerome Kagan's theories (1971, 28-39) basically represent the Freudian concept of a child's primary motives for resolving uncertainty. In this sense, Kagan is in the category of homeostasis theories. On the other hand, when Kagan (ibid., 63-76) a few pages later emphasises the importance of different motives for different ages and life situations, he applies Maslow's hierarchy of needs and thus clearly represents theories of personal growth.

To convey the complexity of the overlapping of these different theories, Kagan's definition of the motive for mastery is illustrative: "the wish to enhance one's knowledge, skill, or talent is related to the motive to resolve uncertainty". This process comes very close to the process of an intrinsic conflict arousing the motivation for solving the conflict.

The next two sections, (3.2. and 3.3.) discuss achievement motivation theory and conflict theory.

3.2. Achievement Motivation

During the last forty years achievement motivation theory has been developed by Atkinson & McClelland, its creators, and by other researchers. At present achievement theories are being developed along many different lines.

Most motivation research is based on the theory of achievement motivation. There are several reasons for this according to Schiefele, Hausser & Scheider (1979): one important factor is that this is the only theory which is both theoretically valid and so well supported by empirical evidence that it can be applied in practice to education in the school classroom. Another important reason for the success of achievement motivation theory is that the school system is based on achievements, and that society demands and encourages this kind of behaviour.

Achievement motivation theory is also the dominant paradigm in educational science. In the 1960s "motivational research became almost synonymous with achievement motivation research" (Weiner 1990, 619).

Research on achievement motivation has undergone important changes, although the basic achievement model has remained untouched (Hakkarainen 1985). Heckhausen (1986, 7-31) characterises the different decades as follows: 1950s - The era of motive measurement; 1960s - The era of motive interaction; 1970s - The era of causal attribution urge; and 1980s - The era of volitional action.

This typology characterises not only the development of achievement motivation theory and research, but also its weak points and reactions towards them. The same typology is used here as a tool for the analysis and criticism of achievement motivation theory.

Motive measurement

The 1950s was the decade of the breakthrough of the theory. It was a hectic time especially for measuring achievement motivation with the TAT-model (= Thematic Apperception Test) formulated by McClelland, Atkinson, Clark & Lowell in 1953.

The TAT-model determines the strength of the motive to succeed. Since the fifties, the Test Anxiety Questionnaire (TAQ) by Mandler & Sarason in 1952, is often used to supplement the TAT. The TAQ shows the strength of the motive to avoid failure (Atkinson 1964).

These tests linked motivation to several other features of human behaviour. The results from achievement motivation tests were considered to be an absolute correlate that could be used in other fields of research on human behaviour. (Heckhausen 1986).

Motive interaction

In the 1960s, achievement motivation theory was made more exact with the risk-taking model (Atkinson 1957; 1964). The main assumption of this model is the interaction between the difficulty of the task and the ability of the learner. The risk-taking model has proved its efficiency in describing

the achievement motivation of success-orientated pupils, but is more problematic with fear-of-failure orientated pupils.

The original assumption of the risk-taking model is that pupils with the fear-of-failure motive avoid so-called intermediate tasks, i.e. situations where they cannot be sure of success. According to many studies, the normal trend is for people to select increasingly difficult tasks from among all those available (Heckhausen 1984; Houtmans 1986, 42-43;).

This is an essential question for learning research and school education: pupils do not learn by completing tasks that are too easy, or when their motivational threshold prevents them from attempting more complex tasks. Even if they have the ability to succeed, learning will not occur.

According to the risk-taking model, pupils with fear-of-failure motivastion will try hardest when they are compelled to carry out intermediate tasks. Heckhausen (1986, 15, 23) has pointed out the difference between motivation and volition in this context: persistence and performance are not problems of motivation, but of volition. Heckhausen (ibid.) distinguishes choosing from doing.

This observation also has important implications for school education: motivation is not at the root of every question about the learning process, although this quasi-explanation is all too easily and frequently given.

The risk-taking model also shows one of the weaknesses of achievement motivation theory: the source of the pupils' fear-of-failure and hope-of-success motivation is not questioned. Yet it is critical to know whether the

task is meaningful to the pupils. Achievement motivation theory does not take into account the background that led each pupil to develop his/her individual motivation. Instead the theory concentrates on the effect of the motivation on the pupils' achievements.

Causal attribution

Causal attribution was made a supplement to achievement motivation theory by Weiner et al (1971). The concept was needed to explain the origin, biological or psychological, of achievement motivation. Causal attribution can thus be seen as an answer to the criticism that achievement motivation was a theory that existed in isolation and was simply assumed, not logically derived.

According to Weiner (1971, 1983, 1984, 1986), the learner's affective and cognitive reactions in situations of success or failure can be explained by causal attribution, with extrinsic (teacher, environment, etc.) and intrinsic (learner's own characteristics) inputs.

Sometimes this type of research is classified as a school of motivation of its own (Korman 1974, 2; Mustila 1990, 27-32), but the basic ideas of such an approach must be considered to represent just one period in the study of achievement motivation.

Atkinson's (1964, 247) often-cited definition of achievement motivation as a "capacity of experiencing pride in accomplishment" was completed with "capacity for perceiving success as caused by internal factors, particularly effort" by Weiner et al (1971, 18). This attributional approach was soon

widely accepted within the field of motivation research, but some criticism was made by the orthodox side (Heckhausen 1986, 21-24). However, without this reform, achievement motivation studies would have become fruitless repetitions of old or old-fashioned results (Ames & Ames 1984). Causal attribution also adds the dimension 'extrinsic/intrinsic' to motivation research.

Motivation or volition

The main topic of attributive motivation research was cognition. When effort becomes the focus of studies, as happened during the eighties, the need to differentiate between volition and motivation becomes apparent (Heckhausen 1986, 23-31).

The traditional view of motivation is to see it as the power to start a process. The problems that occur in more complicated learning processes do not, however, arise at the start but in the continuation and the completion of the process. This has also been noticed by motivation researchers, and they have concentrated on finding the reasons for interruption of learning, i.e. why doesn't motivation last and what makes it weaker? or, why does an action, eagerly started, become foreced and self-driven during the learning process?

Although the problems of volition arose as recently as the eighties, some key elements were recognised by the developers of achievement motivation theory (Atkinson 1964). Achievement alone is not the reason for motivation, and three major elements were found essential in linking motivation to performance: 1. The sum of all outer and inner factors causes motivation.

2. The strength of motivation is reflected in the intensity of effort. 3. The intensity of effort produces the results of the performance.

Heckhausen (1986, 25-30) has listed the characteristics of pure motivation-centred research: 1. Concern with future activities for which one's ability has instrumental value. 2. Activities that place high demands on a central self-relevant concept of ability. 3. Having been attained or not, the first sub-goal is predictive for further performance. 4. The distinction between volition and motivation must be refined.

3.3. Conflict Motivation

The concept of "intrinsic conflict" has been used by Rosenfeld (1973), strongly influence by Leontjev, Rubinstein and Vygotsky. Vepsäläinen (1980, 28-44) has made a thorough analysis and synthesis of Rosenfeld's studies concerning the theory of conflict:

An educator sets children in a conflict situation and gives them tasks that are above their average developmental level. In addition, the educator has to guide the learners to enable them to work out the conflict.

According to the cognitive tradition established by Ausubel (1963) and Bruner (1964; 1986), there is a connection between cognition and motivation. At first Ausubel's concept was very close to Piaget's assimilation-accommodation model, but later he added the motivational element. According to Ausubel's theory, if a child is able to link new information to her existing cognitive structure, then new information becomes meaningful and gives the child the motivation to learn.

The school of activity theory has used this criticism by Ausubel of achievement motivation, but emphasised at the same time that Ausubel's theory only gives the learner a passive role (Hedegaard 1989; see 2.10.).

Bruner (1964) emphasises the possibility of teaching a child things beyond her current level, if that cognitive level is taken into account when planning the teaching. Bruner judged the child's achievements and present ability to be more significant than the content of the new lesson. However in this study the subject-matter itself, human biology, has an important motivational effect.

Vygotski (1982, 265-278) does not accept some of the over- optimistic assumptions of a child's capacity to learn anything. His main argument is that children perform better under the guidance of adults, although even this co-operation does not enable them to solve all the problems. The best results are achieved with the tutorial help of a teacher. In teaching, tasks must prepare children for the next level of their cognitive development (see 2.10.).

Teaching accelerates learning in the most effective way when it is one step ahead of the child's developmental level. This phenomenon can also be used as a motivating factor. Goals are set and seen in a near-future perspective. Vygotski (1982) does not use the concept of "intrinsic conflict" but his ideas of new learning situations, for example when a child comes to school and starts to learn new things in a new situation, include the idea of a conflict to be resolved.

One of Rosenfeld's (1973, 170-182) main results is that the most effective pedagogical situation is one where a conflict is set up in such a way that it creates intrinsic conflict from the child's point of view. It is also important that the children feel able to resolve the conflict and are eager to start the process. Knowing that support is available, even if it is not used, is also a useful affective motivating factor in solving the problem.

The connections between cognition, motivation and action are clear: there is no motive without action, and no action without a motive (Vepsäläinen 1980, 30). Sometimes no action is observed, because motivation can also lead to the decision not to act. In addition, the time lapse between motivation and its effects may vary from one lesson-period to a life-time (Hautamäki 1979).

The school of activity theory has adopted conflict theory as part of its theoretical background in motivation research (see ISCRAT 1990).

In conflict theory, the main factor in generating motivation is the method of giving an instruction to the learner. The reward/punishment model of achievement theory is criticised and rejected. Equally, extrinsic tricks should not be applied to create intrinsic conflict and motivation.

The principles of creating intrinsic motivation through instruction have been classified by Hedegaard (1986, 34-38) as follows:

I General ways of creating motivation

1. Relate the learning material to the children questions about life.
2. Work out learning tasks.
3. Employ learning procedures (parallel to scientific procedures).

II Specific ways of creating motivation in the course of instruction:

1. Working with oppositions, contrasts and conflicts in the educational material.
2. Setting tasks that make the children exploratory activity genuine and not a pseudo-activity where the teacher has the correct solution "up his sleeve".
3. Using class dialogue when the children suggestions and comments can be tried out in a class situation, e.g. by confronting two or more suggested solutions.
4. Using an outline of the lesson plan at the beginning of each lesson.
5. Recording the conclusions and results on a goal/result board.
6. Using class discussion to summarise the main points of each topic, before moving to the next one.
7. Using cooperation among children, in pairs and in groups.
8. Using a comprehensive set of books, chosen according to the content of the instruction.
9. Using a reading period related to the lesson.

These principles are in many senses equivalent to the common recommendations for motivating pupils before a lesson. However, normally more extrinsic tricks are used in motivation instruction, and they are used by teachers mostly at the beginning of the lesson and not during the learning process (Kalske 1984; Tommila 1984).

All the principles under "I: General ways of creating intrinsic motivation" were used in this study's empirical test. However, the exhibit visit was short

and some features of the exhibition restricted the application of "II: Specific ways of creating motivation". These methods of instruction are discussed in chapter 5.3. "How to Create Different Kinds of Motivation?"

The definition of motivation in conflict theory is open to challenge. Is there basically any difference between conflict theory and homeostasis theory? Is the process of getting rid of the emotional pressure caused by the conflict the same in both cases? Compared with homeostasis theory, conflict theory emphasises the social nature of the intrinsic conflict. However, by emphasising the influence of society on motivation some relevant features of the individual may be hidden. Conflict theory also includes factors of authority and control, e.g. the idea of the educator's ability to know what is best for the learner.

The main source of intrinsic motivation is the positive conflict between people, i.e. the learner and the teachers and other learners. Conflict arises when the learner's and the other person's ideas, skills, theories and opinions are in conflict or incompatible, but a common solution is being actively searched for (Harter & Connell 1984; Ryan, Connell & Deci 1985; Condry 1987). The main difference between this approach and that of Vepsäläinen (1980) is that the conflict is defined on a larger scale, i.e. between the learner and an environment that consists of family, peer group, society as a whole, and the demands and extrinsic elements of life.

Most researchers agree on the key elements in the process of generating intrinsic motivation. Intrinsic conflict initiates the learning process by which the learner tries to resolve the conflict by applying new knowledge, skills and theories, or by reorganising her existing cognitive structure (Johnson &

Johnson 1979). Problem-based tasks and real-life situations are good ways of trying to orientate the learning towards the underlying mechanism of the phenomenon studied (de Volder et al 1986, 219). This point of view is very similar to the idea of learning the theoretical background to a topic and not only isolated facts (see 3.5.; Engeström 1984; Ropo 1984). Another educational method is to ask questions and set problems in order to make students eager to learn. These methods are applied in the empirical part of this study in order to induce intrinsic motivation in pupils (see chapter 5).

Conflict theory is a very strict and theoretical model, and neglects some characteristic features of every-day situations. The model is based on an ideal situation, which cannot exist in a society with a strong in-built idea of competition.

3.4. Extrinsic versus Intrinsic Motivation

Intrinsic motivation is a state of mind and of behaviour found (as are most educational ideas) in several historical works, for example in Rousseau. However, it becomes more relevant in the theories of Jean Piaget and Jerome Bruner. In general, the origin of intrinsic motivation is considered to be the fact that human beings "are born curious about the world, and this inherent curiosity provides the motive force for most of what we learn when we are free to explore the world on our own" (Condry 1987, 25).

Extrinsic motivation is most often described and defined as being very close to or even synonymous with achievement motivation. And yet conflict theory has tried to claim intrinsic motivation as its own property. However, since the 1970s intrinsic motivation theories have mostly been developed

within the frame of achievement motivation theories. The question of extrinsic vs. intrinsic motivation is strongly developing as one of the main dimensions of motivation research (cf. Weiner 1990).
Several categories of extrinsic motivation can be identified. For example Deci et al (1991) identify four types of extrinsic motivation: external, introjected, identified, and integrated forms of regulation.

Intrinsic motivation is very often presented in the light of conflict and as an alternative to extrinsic motivation. Especially in the 1970s these two forms appeared to be in opposition (Weiner & Al. 1990): curiosity, intrinsic interest and exploratory problem-based learning are regarded as typical features of intrinsic motivation; as opposed to social control, offers of reward and threats of punishment, which are typical of extrinsic motivation.

There are several terms in the literature that refer more or less to the same phenomenon. de Volder et al (1986, 217) have found seven terms frequently used: intrinsic or continuing or cognitive motivation; subject related affect or attitude or interest; and epistemic curiosity. No clear boundaries can be drawn between these terms with reference to the measurement instruments used in these studies.

Intrinsic motivation is often defined as motivation towards activities that have no apparent reward beyond the activity itself. The experience of working or learning feels rewarding to the learner (Deci 1975); and intrinsically motivated behaviour is often engaged in for its own sake - for the pleasure and satisfaction derived from performance (Deci & Ryan 1985).

Intrinsic motivation has, since the middle of the 1970s, been defined as arising from the importance and relevance of the learning content to the learner (Fransson 1977). Epistemic curiosity and cognitive motivation are the terms most often used, while knowledge an sich is the main positive motive for learning (de Volder & Al. 1986, 217).

de Volder at al (1986, 217-218) note that the term intrinsic motivation is not very informative without further definition. It cannot be used like the established term "achievement motivation".

Harter & Connell (1984, 219-249) have studied the relation of some typical features of children's behaviour to motivation. They interpret exploration, mastery attempts, play and curiosity as an intrinsic need to deal with one's environment. Harter & Connell (1984, 227-249) found these factors essential to the development of intrinsic motivation. They also identified the key elements of intrinsic motivation as follows: 1. Preference for challenge (is the child intrinsically motivated to seek challenging material in order to learn or master). 2. Curiosity (is the child intrinsically motivated to learn new things, is she inquisitive). 3. Independent mastery (is the child motivated to figure things out on her own).

In recent research Condry (1987, 24-26) has recognised three types of intrinsic motivation models:

1. Competence: Intrinsic motivation is viewed in terms of competence, mastery or efficiency. Learning activities are intrinsically motivating if they engage the pupils in problem solving and goal seeking. The result gives a

sense of mastery to the learner. Kagan (1971), Csikszentmihalyi (1979) and Harter & Connell (1984) have achieved results based on this approach.

2. Curiosity: Studies have focused on "stimulus characteristics" that arouse curiosity. Intrinsic motivation and active exploration and learning follow from attention, interest and curiosity. This approach is represented by Berlyne (1960; 1978) and Keller (1987).

3. Personal control: The activity is intrinsically motivating when it gives the learner some degree of personal control and self-determination. The result gives the learner a sense of personal effectivity. For example Deci (1975), Johnson & Johnson (1985), de Charms (1987) and Condry (1987) emphasise the importance of the lack of social control over the learning process as a key element for intrinsic motivation.

These three models differ but are not incompatible. However a fourth model, conflict theory, is based on a theoretically different approach, as presented in section 3.3.

There is a clear difference between the classical Atkinson-type achievement motivation and mastery motivation: achievement motivation is, in most studies, described as the level of motivation that the subject needs to reach his/her goals encouraged by success. Mastery motivation, on the other hand, describes motivation orientation with reference to the pupil's position (Harter & Connell 1984, 219-222).

The pupil's motivation stance is caused by either intrinsic or extrinsic reasons: challenging work, enjoyable tasks, curiosity-based problems often

create intrinsic motivation. External approval by teacher, parents and peer group, exam grades and the demands of the educational system are typical factors of extrinsic motivation orientation (ibid., 222).

Children make clear distinctions between different features of learning and education; they can be described as follows (ibid. 227-228):

1. Preference for challenge versus preference for easy work assigned.
2. Incentive to work in order to satisfy one's own interest and curiosity versus working in order to please the teacher and to obtain good grades.
3. Independent mastery attempts versus dependence on the teacher.
4. Independent judgement versus reliance on the teacher's judgement.
5. Internal criteria for success/failure versus external criteria.

As an instrument to study Intrinsic vs. Extrinsic motivation orientation, correlation pathway analysis has often been used. The pathway diagram is more complex at the junior high school level than at primary school. The intrinsically motivated pupils want to determine what they study, and feel that they are capable of making autonomous decisions concerning their studies. The extrinsically motivated pupils prefer to rely on teachers' judgments (Harter & Connell 1984, 239-240).

3.5. Motivation and Learning

Motivation has been studied mostly in relation to learning. However, it is as important to concentrate on motivation an sich (Deci et al 1991). In this study, the links between different types of motivation and learning are important, and the results of motivation treatment form an independent part of the study.

Research into learning styles and strategies has become an important part of educational science. The main conclusion from research is that individuals have different learning styles and that, by varying these styles, they form their own learning strategies which they apply in different situations. The most varied learning strategies give the learner the best opportunity to adapt herself to new situations without wasting time on a long orientation period before the actual learning. Teaching, and other means of arranging the structure of the learning process, have a major effect on the development of learning strategies (Entwistle 1981; Keefe 1979; Ropo 1984; von Wright, Vauras & Reijonen 1979; Vauras & von Wright 1981; Marton & Säljö 1976; Marton 1980, 1983; Leino 1981, 1982; Pask 1976; Hein, I. 1987; Weinstein & Mayer 1986).

Surface and deep learning are the two main types of learning strategy (e.g. Marton & Säljö 1976; Marton 1980, 1983), and are commonly used by students when studying for an exam. Typical to surface learning is the learner's attempt to remember the text literally; the learning process is atomistic; the content is not meaningful, and the learner is alienated from the learning process - the main purpose is to pass the exam.

A student with a deep learning strategy tries to understand the meaning, the message and the theoretical basis of the topic; the learner is trying to get a holistic view of the topic, its structure, its key concepts and principles; the learner is also maintaining a critical attitude towards the topic and the usefulness of the information.

A student who applies the surface strategy may, immediately after the learning period, remember a relatively large number of isolated facts. The

deep learning strategy produces an essentially better ability to analyse the studied topic, to observe the links between isolated phenomena and to apply the knowledge to new problems. The deep learning strategy also makes it easier to memorise isolated facts: surface learned facts tend to be forgotten quickly, but a deeply learned structure makes it possible to link isolated facts into a meaningful entity that is less easily forgotten. (Marton & Al. 1976, 1980, 1983; Engeström 1984; 25-26).

Schools and universities often encourage the use of a surface learning strategy. One reason is the great amount of information and the large number of courses: all information cannot be understood - or at least not learned. Remembering is possible for a short period only. This trend is strengthened by the use of examination questions that mainly require an ability to learn isolated facts by rote. However, this does not mean that grades, examinations and tests automatically lead to false instrumental motivation and to surface learning strategy (Engeström 1984, 26).

This way of learning, teaching and controlling education is often justified by lack of time or cost-effectiveness which, however, turns out to be false. The problem is that when a pupil has once adopted the surface learning strategy, it is very difficult to change to the deep learning strategy. By contrast, the deep learning strategy is surprisingly easily disrupted by external factors. (Engeström 1984, 26).

Learning is judged to be meaningful if it is relevant to the learner's own needs and schemes. It is typical of meaningful learning that the learner sets the goals herself, orients to the future, and feels that things are meaningful

in different ways; the context of learning is also significant (Olkinuora 1983).

Deci et al (1991) have reported interesting results from the application of the theory of self-determination learning. Intrinsic motivation resulted in high-quality learning and conceptual understanding in several cases, from early elementary school to college.

Meaningful learning is closely related to motivation and to learning strategies (Weinstein & Mayer 1986, 315-325). Relevance, and the learner's own ability to control the learning process, are the key elements in meaningful learning.

3.6. Motivation Studies in Science Centres

Every-day knowledge tells us that pupils are eager to have lessons in informal settings. Field trips, camp schools, visits to industry, to a museum or science centre - even having an art lesson in the school yard - are positive occasions in pupils' minds. The roots of this positive attitude are in the freedom of leaving the classroom. This free feeling arises as much from the wish to avoid school as from positive motivation towards the informal learning goal.

Physical context can also have a strong positive effect on learning (see 2.10).

Can the motivating effects of freedom and physical context be taken advantage of? This is the aim of science centre education. There is also a

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wider context: environmental determinants have again (as in the 1940s!) become the focus of motivation research (cf. Weiner 1990).

Motivation has rarely been studied in informal learning settings. This is strange, because motivation is emphasised in most science centres' educational goals (St. John 1987). Yet positive motivation might be deemed so self-evident that its role has been neglected in the educational research of science centres. Another reason for its neglect is that there has been a stronger need to demonstrate the cognitive benefits of science centre education to the school authorities.

Stephen Bitgood's (1989a, 1989c) exceptionally comprehensive bibliography of the research into school visits (N=92) to educational centres includes only one study (Hertel, B. 1979) naming "motivation". Examination of other bibliographies gives equally fruitless results.

However, terms such as "attitude", "affective response" and "positive for science" are often used in the titles, outcomes and effects of the studies (Bitgood 1989a). In some studies of science centres, motivation has been a secondary subject of research. It is also possible that the phenomenon has not been labelled "motivation" in the literature, or that where the word is used it is not precisely defined. One of the few exceptions is Screven (1992) who distinguishs between intrinsic and external ways of motivating visitors to read text-labels. Because of the lack of research specifically into motivation in science centre learning, studies that touch on the subject have also been included here.

Wellington (1989, 30-33) classified the educational aims of a science centre by studying the active discovery learning which clearly occurs when people interact with exhibits. He identified the contribution of science centres to schools, and also to the public understanding of science. On the basis of Bloom's well-known taxonomy, he classifies the educational aims as shown in Table 3.1.:

Table 3.1. Educational aims of science centres.

Cognitive	Psychomotor	Affective
Knowledge THAT	Manipulative skill	Interest Enthusiasm
Knowledge HOW	Manual dexterity	Motivation Involvement
Knowledge WHY	Hand-to-eye co-ordination	Eagerness to learn
Synthesis		Awareness and Openness
Understanding		

Wellington's classification (table above) has clear relevance to the role of motivation in science centre learning.

"Knowledge THAT" indicates that the pupil gets interested in the topic, often because of the attractive design of an exhibit, which encourages the pupil to use her manipulative skills. This stage is compared to situation motivation.

"Knowledge HOW" demands manual dexterity in the sense of not only pulling a knob or turning a handle. Wellington (1989, 30-31) calls the affective results "involvement" and "motivation", but this is more analogous to the term instrumental motivation.

"Knowledge WHY" has its basis in hand-to-eye co-ordination in the psychomotor learning process, leading to eagerness to learn. Going through the entire process from first to later stages will lead the pupil close to the level described as intrinsic motivation.

The different levels of learning and motivation are related. Some studies have even shown that there is no statistically significant difference between different teaching and learning methods. "Active research role play" and traditional lectures were equally effective in teaching astronomy (Vahtera 1991). However, pupils motivated towards active learning were more positively motivated towards the process and were also interested in learning more about the topic.

Eagerness and personal activity in learning are often mentioned as the key elements of the behaviour of adults, children and pupils in science centres. Studies have dealt mainly with cognitive results for reasons outlined above, although affective gain seems to be more typical of science centre learning

(Pittman-Gelles 1981; Borun et al 1983; Carlisle 1985; McManus 1985; Finson & Enochs 1987; Javlekar 1989; Falk & Dierking 1992).

3.7. The Model for Motivation: Situation, Instrumental and Intrinsic Motivation

Intrinsic vs. extrinsic motivation has become the focus of recent motivation research. It has even built a bridge between theoretically different approaches to motivation.

Engeström (1984, 28-34) finds three motivation types: Situation motivation, Instrumental motivation and Intrinsic motivation. In this study, Situation motivation and Instrumental motivation are classified as different types of Extrinsic motivation. Only one type of Intrinsic motivation is used here.

The main argument for discussing these types of motivation is to study the relation between motivation type and learning strategy. However the term Intrinsic motivation has been expanded from Engeström's (1984) narrow definition to its broader meaning, as influenced by the theories analysed above (see 3.4.).

It must be emphasised that "intrinsic conflict" cannot be solved only inside the learner's head, since activity is often necessary to resolve these conflicts in the real world around us. This also explains the main difference between the terms "content based" (=sisällöllinen; Engeström 1984) and "intrinsic" ("sisäsyntyinen") motivation.

In this study the term "intrinsic motivation" is used much as Engeström uses it, although the theoretical background to his term is not that of achievement motivation theory. Some elements, for example curiosity and play, have been added to Engeström's model. The main reason for using the term "intrinsic" instead of "content based" is that the instrumentalisation of these two types of motivation is nearly identical.

The particular terms in this study (Situation, Instrumental, Intrinsic) are also used for semantic reasons. For example, Engeström's model can be compared with that of Brown (1981), who defines motivation on three levels: Situation/specific motivation, Task-oriented motivation and Global motivation. These are the same motivation types as Engeström's, but with different names. There is no good reason to increase even further the numerous, slighly different terms in educational science.

A: Extrinsic motivation

Situation motivation: Motivation grows from a new situation. Temporary, external factors are important. Social relations are often an affective factor. Entertainment is always a significant factor.

Typical features:
- short-lasting motivation
- learning is easily disturbed
- learning is oriented to irrelevant subjects

Instrumental motivation: The basis of this motivation is to get a reward and/or to avoid punishment. The main stimulus is "to get things done" rather than being interested in the deeper meaning of the subject.

Typical features:
- the goal is often to pass an examination
- learning of isolated facts; but common principles, connections or a theoretical background less important for learner
- facts are very quickly forgotten after the examination

B: Intrinsic motivation

Intrinsic motivation: The basis of this motivation is a real interest in the topic of study. No other person persuades the learner to learn. She sees the value of the studies and already has plans to use the knowledge or skill in the future. Curiosity, exploring and problem solving are key elements of the motivation.

Typical features:
- a critical and open-minded attitude towards learning
- seeing the connection between isolated facts and the topic area as a whole
- connection between theory and practice
- curiosity, interest, problem-based learning

Although most studies of motivation orientation have been conducted in the classroom learning context, the model is also useful in this study concerning learning in informal settings. The distinction between intrinsic and extrinsic (situation and instrumental) motivation give the study a theoretical background.

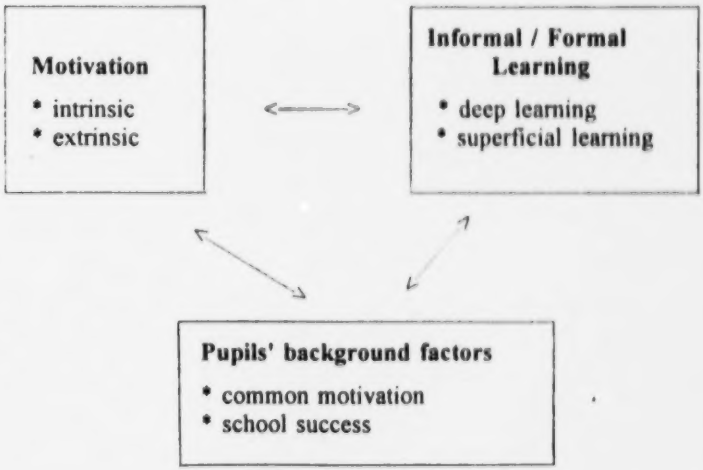
Engeström's model is used in this study to measure motivation types. The model is practical, but was developed mainly for adult education situations. A child is perhaps not so conscious of her goals and needs as to be able to plan and see the basic purpose of her studies.

Therefore, several elements have been added to Engeström's theory. These include especially the elements of challenge, personal interest, self-determination, conceptual understanding, active curiosity, personal reasons for mastery and choice of study topics. Further elements derived from the work of researchers discussed in this chapter also contribute to the model outlined above (under the headings A: Extrinsic motivation and B: Intrinsic motivation) .

With these additions, intrinsic motivation theory is theoretically and empirically the most comprehensive way of approaching motivation. Therefore, it is chosen as the theoretical background for the present study.

The context of this study is shown in figure 3.A.

Figure 3.A Context of The Study



The figure above shows the relations between the key elements of this study. In educational reality, there are numerous connections between all these elements. In this study, only the relations marked with arrows are evaluated.

The arrows between the boxes do not show actual effects, but show the theoretical basis for the methodology of this study (i.e. theory, problems, hypotheses, design and assessment). The results and their analysis can also be read in this context.

The structure of the study can be summarised as follows:

Motivation is the main element of the study.

Intrinsic motivation and two kinds of extrinsic motivation (instrumental and situation) are created by different treatments of groups of pupils.

The relation between motivation and learning is very complex. In this study, the theoretical connection between 1) intrinsic motivation and deep learning, and 2) extrinsic motivation and surface learning, are empirically estimated.

The learning process takes place in an informal education environment.

Pupils' background is assessed in two ways: 1. School success as a measure of their academic subjects, 2. A pre-test measuring their common intrinsic and instrumental motivation.

The teacher's role and the classroom environment have been excluded from the study.

4. AIMS OF THE STUDY

4.1. Research objectives

The goal of the empirical study is to answer the following questions:

1. Do pupils learn new information (scientific facts, concepts) from a visit to a science exhibition?

2. What is the advantage of preparing for the visit beforehand?

3. Do different kinds of motivation affect the quality of learning resulting from the science exhibition visit?

4. Is it possible - by different treatments - to create different kinds of motivation in groups of pupils?

These questions are practical and directly relevant to the way learning in a science centre is organized. However, they are also of wider theoretical interest: the study was designed to test the theory of intrinsic, instrumental and situation motivation. Results can also inform the link between formal and informal education, and have potential applications in schools.

4.2. Hypotheses

The following hypotheses are derived from motivation theory, as related to the special conditions of informal education in science centre settings. The number

of each hypothesis refers to the question numbers above. However, there are several other links between the hypotheses.

Main Hypothesis: The intrinsic motivation group is deep-learning oriented; the instrumental motivation and situation motivation groups are surface-learning orientated.

Hypothesis 1: Learning is achieved through a visit to a science centre.

Hypothesis 2: School classes that have a pre-lesson before a visit to a science exhibition gain cognitive advantage, and learn better than other groups having no pre-lesson.

Hypothesis 3: Different kinds of motivation affect the quality of learning from the exhibition.

Hypothesis 3a: School classes with intrinsic motivation learn entities better than classes having instrumental or situation motivation.

Hypothesis 3b: School classes with instrumental motivation learn isolated facts better than other groups.

Hypothesis 3c: Constancy of learning is longer-lasting for the intrinsic motivation group than for the other motivation groups.

Hypothesis 4: Different types of motivation treatment arouse different kinds of learning motivation.

Hypothesis 4a: The intrinsic motivation group is more positively motivated towards the science exhibition than other groups.

Hypothesis 4b: Intrinsic motivation is longer-lasting than the instrumental or situation motivation.

Hypothesis 4c: Instrumental motivation is not long-lasting.

Note: The pre-lesson, the treatments designed to arouse different kinds of motivation (intrinsic, instrumental and situation), the conditions of the visit, and the pre- and post-visit tests are described in chapter 5: Methods.

5. METHODS

5.1. Design

The design of this study is a typical quasi-experiment (cf. Cook & Campbell 1979; Glass 1988) as shown below:

Table 5.1. Design of the study

$O_{1a,b}$	X_{2I}	E	$O_{3a,b,c,d}$	$O_{4a,b,c,d}$
$O_{1a,b}$	X_{2II}	E	$O_{3a,b,c,d}$	$O_{4a,b,c,d}$
$O_{1a,b}$	X_{2III}	E	$O_{3a,b,c,d}$	$O_{4a,b,c,d}$

Time: T_0 T_1 T_2

O_{1a} Intrinsic motivation test (pre-test)
O_{1b} Instrumental motivation test (pre-test)

X_{2I} Treatment: intrinsic motivation
X_{2II} Treatment: instrumental motivation
X_{2III} No-treatment: situation motivation

E EXHIBITION VISIT

O_{3a} Intrinsic motivation test (post-test)
O_{3b} Instrumental motivation test (post-test)
O_{3c} Situation motivation test (post-test)
O_{3d} Knowledge test (post-test)

O_{4a} Intrinsic motivation test (delayed post-test)
O_{4b} Instrumental motivation test (delayed post-test)
O_{4c} Situation motivation test (delayed post-test)
O_{4d} Knowledge test (delayed post-test)

Pre-tests administered three months before the exhibition visit ($=T_0$).
Post-tests administered three days after the exhibition visit ($=T_1$).
Delayed post-tests administered six months after the exhibition visit ($=T_2$).
Treatment (X_2; motivation manipulation) administered one week before the exhibition visit (E).

5.2. Subjects

Six school classes of 7th graders (aged 13-14) were chosen for the test at random. Altogether there were 168 pupils from the greater Helsinki area.

There were two reasons for the selection of 7th-grade pupils as the subjects of this study: 1. They are the most typical groups to visit the exhibition, because most 7th-grade classes in greater Helsinki visit the exhibition following the guidelines of the school administration. 2. It can be supposed that this age group had the most homogeneous background knowledge of the subject of the exhibition because, in accordance with Finland's National Curriculum (Komiteamietintö 1970B) and school practice, human biology is a topic for the 5th grade and again for the 9th grade, but not for the 7th grade: the way the topic had been taught two years earlier did not have a strong, direct effect on the pupils' level of knowledge.

The classes were chosen from different schools. Hence, potential problems concerning validity were avoided: specifically, the weakening of the test-effect and competition or co-operation between classes and teachers were prevented (Cook & Campbell 1979, 43-53). The schools were located in different areas of greater Helsinki.

5.3. Treatments: How to Create Different Kinds of Motivation?

The theoretical background to intrinsic, instrumental and situation motivation is presented in chapter 3. The different qualities of motivation are often the topic of motivation research. However, the approach has been to investigate the

Table 5.2. The subjects of the study

	Girls	Boys	Total
Group I:			
School A	16	13	29
School B	12	13	25
Group II:			
School C	12	17	29
School D	14	12	26
Group III:			
School E	11	17	28
School F	14	17	31
Total	**79**	**89**	**168**

different patterns of existing motivation, and there are only a few studies in which the possibility and effectiveness of creating motivation by instruction have been studied (e.g. Marton 1980; Kalske 1985; Hedegaard 1986).

Instruction is the key element in creating motivation. There is a clear relationship between students' motivational patterns and their preferences for different instructional methods, especially in science education (Kempa & Diaz 1990a, 1990b).

The instrumentalisation of different kinds of motivation was based on Engeström's model (3.6.). In the process, the principle of creating motivation by instruction (3.4.; Hedegaard 1986) was applied. A problem-based task and related questions are essential for the creation of deep, learning oriented motivation. Also, the effect of a graded school test is more dramatic than generally supposed (Marton 1980, 86-97).

5.3.1. Pre-lesson

A pre-lesson is normally used to make learning from a science centre visit more effective. Here, the pre-lesson was used as a tool for the treatment.

Groups I & II had a pre-lesson, and group III did not.

Groups I,II,III were treated so that each group had a different quality of motivation:
Group I was treated to have intrinsic motivation.
Group II was treated to have instrumental motivation.
Group III was treated to have situation motivation.

Pre-lesson treatment was given to the classes (A,B,C,D) by the same person. Lessons included the same cognitive knowledge. In particular, the content of the isolated facts test (see 5.4.1.) was taught carefully. The main theme of the guided tour, Blood Circulation, was also mentioned.

Intrinsic motivation was created for group I (with a pre-lesson). During the pre-lesson, they were given a question concerning their own health "Study of my body" and the task of making observations from the exhibition. The pupils of the intrinsic motivation group were told that the reason for the test after the visit was to get feed-back from the teenagers, for the planners of the exhibition to develop the science centre more from the youngsters' point of view.

Instrumental motivation was created for group II (with a pre-lesson). They were told before the pre-lesson, as well as at the beginning and at the end of the exhibition visit, that they were going to have a test concerning the pre-lesson and

the exhibition visit, and that the test would have an effect on their next school report.

Situation motivation was created for group III (with no pre-lesson) by the external factors of the visit itself, such as: attractive equipment, temporary situation, novelty of situation, the sudden change from school routine, the affective stimulus of exhibits and social relations with friends. The group was informed no earlier than two days before their visit that they would go to the exhibition . The exhibition an sich was supposed to produce situation motivation.

The other groups experienced, of course, the same exhibition effect, but this is not a pure situation motivation effect because of their intrinsic/instrumental pre-treatments.

5.3.2. The Guided Tour

The groups visited the Pulssi ('Pulse') exhibition (1200 sq m), which was arranged in Helsinki in 1985 by the Science Centre Foundation and Finland's medical science organisations as a pre-exhibition for the planned science centre Heureka. The topic of the exhibition was medical science and human health. The exhibition consisted of fourteen sections, in the style typical of an interactive science exhibition (Tiedekeskussäätiö 1985, Quin 1989).

The exhibition visit was the same for all groups. The classes first had a guided tour (60 minutes) and then the pupils were allowed to go through the exhibition on their own (30 minutes). The contents of the guided tours were made as identical as possible (see 4.6.4.; 8.2.).

The theme for the visit was "Blood circulation". Eight of the fourteen different sections were linked together by this theme (see table 5.3.). The guided tour also contained several isolated facts measured by the tests (see 5.4.1).

Table 5.3. Theme and the content of the guided tour.

Section	Topic	Connection to blood circulation
Bones	The meaning of the bones	Blood cell production in bone marrow
Lungs	The function of lungs and abdominal breathing: muscle work	Oxygen and carbon dioxide in breathing and blood circulation
Heart	Structure and function The composition of blood	Heart and blood circulation Systemic circulation Pulmonary circulation
Sense of balance	The structure and function of equilibrium organs	
Sleep-lab	Why sleep? What are dreams?	Human body functions and blood circulation during sleep
Patient	Hospital routines First aid	Oxygen in blood circulation Circulation with respect to waste products, antibodies and hormones Transportation of nutrients
Physical condition	Sport and health	Oxygen and carbon dioxide in circulation Heat production and distribution Hormones (e.g. adrenalin) carried in blood stream Waste products and circulation
Teeth, dentist	Function of teeth Care of teeth	

After the guided tour the pupils had a period to wander freely in the exhibition. They were allowed to see new sections of the exhibition or to go back to sections already visited together with the class and guide. It is important for pupils to have "a time of their own" for "free wandering". In pupils' minds there is a very real gap between task-time and own-time (Hautamäki & Salmi 1988).

5.4. Assessment

The pupils were tested by four tests introduced and analysed below.

The general motivation test (Rosenfeld-type standard test, Finnish version/Vepsäläinen 1984; applied), administered as the pre-test, post-test and delayed post-test for intrinsic and instrumental motivation.

The specific motivation test for the exhibition experience, administered as the post-test and delayed post-test for situation motivation.

The Knowledge test measuring the cognitive learning of entities and isolated facts was constructed for this study; it was administered as the post-test and delayed post-test.

5.4.1. Intrinsic Motivation Test (see Appendix 1)

Intrinsic motivation is measured by a Rosenfeld type (Finnish version; Vepsäläinen 1980; applied) motivation test consisting of seven items.

The original test by Vepsäläinen (1980) has 33 items for different attributions of motivation. Here, seven of them were chosen for measuring intrinsic motivation.

The items were chosen to represent the characteristic features of intrinsic motivation (see 3.7.): real interest in the topic, no other person forcing the learning, learner sees the value of the learning; curiosity, exploration and problem solving are key elements of the motivation.

Each item gave a score of 1 to 5 points. The minimum score is therefore 7 and the maximum is 35 points.

An example from the Intrinsic motivation test - item: "I eagerly set about doing even difficult tasks when I find them meaningful to me." (1= agree strongly, 2=agree; 3=agree a bit, 4= disagree; 5= disagree strongly).

The direction of the test scores in the Intrinsic motivation and Instrumental motivation tests was changed when reporting the results to make them easier and more logical to interpret; i.e. higher scores indicate higher motivation.

5.4.2. Instrumental Motivation Test (see Appendix 2)

Instrumental motivation is measured by a Rosenfeld type (Finnish version; Vepsäläinen 1980; applied) motivation test consisting of twelve items.

The original test by Vepsäläinen (1980) has 33 items for different attributions of motivation. Here, twelve of them were chosen for measuring instrumental motivation.

The items were chosen to represent the characteristic features of instrumental motivation (see 3.7.): the basis of motivation is to get a reward and/or to avoid punishment; to get things done rather than for interest; the context in which learning takes place is important.

Each item gave a score of 1 to 5 points. The minimum score is therefore 12 and the maximum 60 points.

An example from the Instrumental motivation test -item: "I would work hard at school, if I was better rewarded for my achievement." (1= agree strongly, 2=agree; 3=agree a bit, 4= disagree; 5 = disagree strongly).

5.4.3. Situation Motivation Test (see Appendix 3)

A science centre or any other exhibition, and an out-of-school visit an sich has a very strong situation motivation effect on pupils. The situation motivation test measures this 'Exhibition experience'.

This effect can be so strong that it easily enhances other learning experiences or efforts made by a teacher or guide (Falk, Martin & Balling 1978; Falk & Dierking 1992, 47-51).

Therefore, this test is constructed to measure the pupils' motivation towards the exhibition. On the basis of motivation theory and the key elements of science exhibition learning (c.f. chapters 1-3) four aspects were chosen to be measured: A. Entertainment. B. Learning. C. Time. D. Knowledge interest.

A. The terms entertainment and fun are very often discussed in relation to science centre education. For example, it was the theme of the ASTC Annual Conference 1990 (ASTC 1990; Salmi 1990). Entertainment, fun and jokes are also among the main features of situation motivation (Engeström 1984). Therefore, one of the items (no. 1) of the motivation test measures pupils' sense of having fun in the exhibition.

B. Pupils actual learning can be shown by the knowledge test, but maybe even more important is the pupils' own perception. Do they feel that they have really learned something? Learning has direct links to intrinsic, instrumental and situation motivation, and to the basic idea of the science centre visit. Therefore, one item (no. 2) of the motivation test measures pupils' motivation towards the exhibition as a learning experience.

Another item (no. 6) measures pupils opinion concerning learning and the guided tour: Was it too difficult, too simple or suitable?

C. Time measurement is one of the classic tools of research into science centre visits (e.g. Falk 1983b; Bitgood 1989). Another important factor is the strong effect in pupils' minds of splitting the visit into a controlled period and an "own time" period (Hautamäki & Salmi 1988). Time is also an essential component of the different motivations: situation motivation is short-lasting, instrumental motivation results in wanting to get things done with minimum effort and least time, and intrinsic motivation is not bound by time limits. However, in this study time is not measured quantitatively, but as a feeling: was the "own time" period long enough? This indicates motivation and motivational quality (item no. 3).

D. Knowledge interest is the fourth aspect in the motivation test. It has a direct link both to motivation and to the principles of science centre learning: one of the main goals of science centres is not only to teach new facts, but also to stimulate critical thinking, imagination and new questions concerning the topic. Real interest in knowledge also differs between the motivational groups: the interest of the situation motivation group changes in response to external effects; the instrumental motivation group maintains interest only over the test period, while under the influence of sanction/reward; and the intrinsic motivation group has a deeper interest in the topic.

A classic, but almost forgotten, method of measuring interest is that used by Luria (1976): giving the learner an opportunity to ask questions about the topic can measure imagination as well as knowledge interest. The fear of making mistakes is much smaller than in a normal test. This is an advance for pupils who do not perform well in traditional school tests (item no. 4).

Knowledge interest is also measured (item no. 5) as a reason for learning, e.g. how useful the exhibition is for school grades (=instrumental motivation).

The item no. 4 gave a score of 0 to 4, and other items gave scores of 1 to 5.

5.4.4. Knowledge Test (Appendix 4)

This test consisting of 21 items was constructed on the basis of the content of the exhibition and pupils' earlier knowledge (see 4.4.).

In the test there where three types of items:

1. Isolated Facts (6 items: nos. 2,7,9,10,12,17-20)

The isolated facts test demands one-word answers, exact values and numbers, which can be learned by rote. It is not important to know the relation of the fact to the entity, or the links between different isolated facts forming the entity.

These items measure isolated facts that were told only in the exhibition by the guide and/or by different demonstrations.

All groups had an equal opportunity of answering correctly. These isolated facts had not been taught during the pre-lesson. The only help from the pre-lessons might have been a slight transfer effect.

The items demand numeric answers (for example: 30 litres), multiple-choice (alternative 1 to 5) answers, or short one-word written answers (e.g. "cupping'). For each question, the score was one or zero. So the minimum score for the test is 0 and the maximum 9.

An example from the Only Exhibition Isolated Fact test - item:
"How many litres of blood can the heart of a top athlete pump in a minute? a) 40 b) 30 c) 20 d) 10 e) 5 litres?"

2. Pre-Lesson and Exhibition Facts (6 items: nos. 1,3,5,6,14,16)

The groups with a pre-lesson have a better chance of answering correctly, because the topic was taught during the pre-lesson and then repeated in the exhibition.

The items demand either exact numeric answers (for example: 206 bones), multiple-choice (alternatives 1 to 5) answers, or short one-word written answers (e.g. "caries"). For each question it is possible to score one or zero. So the minimum score is 0 and the maximum 6.

An example from the Pre-Lesson and Exhibition Facts test - item:
"How many bones does a human skeleton have? a) 76 b) 96 c) 127 d) 196 e) 206?"

3a: Entity Essay Test (one item: no. 18)

This measures the understanding and learning of the main theme "Blood circulation" from the guided tour in the exhibition.

Every section of the exhibition was linked to the theme "Blood circulation". For example, in the sleep research laboratory, besides giving sleep and dream information the guide explained that the heart continues pumping during sleep, but that the pulse and blood pressure are different. During the guided tour, all the main features of blood circulation were taught.

In the Essay Test the maximum score is 6 and the minimum 0.

3b: Learning Entities Test (6 items: nos. 4,8,11,13,15,21)

Five short written answers to questions, and one essay, measure the understanding and learning of entities in the exhibition. Item 8 gives 0-1 points; items 11, 13 and 15 give 0-2 points; item 4 gives 0-4 points and item 21 gives 0-6 points. The maximum score is 17 and the minimum 0.

In the context of this study, the Entity Tests measure results at the holistic level of understanding (see 3.5.)

5.4.5. Observation

The guided tours were followed by an observer, whose task was to observe the guiding. Time table, guide's talk, disturbances, misbehaviour, activity, questions by the pupils, rush, and teacher's role were noted every five minutes or at each of the sections. The emotional relation between the group and the guide was also observed.

The guided tour was also recorded on a pocket tape recorder, but (largely because of the difficulty and quality of the recordings) the only use for these tapes was to give feed-back to the guide himself. It is possible to observe a group in an exhibition without disturbing their natural interaction (Evertson & Green 1986; Lucas, McManus & Thomas 1986). The advantage gained from better recordings would have been smaller than the Hawthorne-effect caused by the disturbing arrangements.

The role of the guide is very important in the design of this study. Before the visits, the guide (a 4th year medical student) was carefully trained in the content, way of talking, demonstrations, time table and theme "Blood circulation" of the guided tour he was to give.

The guide did not know the detailed design of the study. Of course, he had no exact information about the different pre-treatments and quality of motivation of the groups.

The guide made a personal report on all the groups. This report was made immediately after the tour, and included the guide's relation to pupils and teacher, his opinion about the pupils' attentiveness, his observations on the class, any disturbances and misbehaviour and other free comments.

One pupil from every group was followed by an observer, after the guided tour during his/her own time. The pupil's route, main activities, social context, etc. were recorded.

The observations were made mostly to ensure the reliability and validity of the study. They also give valuable information, which confirms the results of the other tests.

5.5. Procedures

Contacts with schools were made three months before the visit to the exhibition. Teachers were given preliminary information concerning the visit.

The study did not measure the role of the teacher, and this fact was stressed to the teachers. This is important, because otherwise teachers would have been on the alert, or might have given extra training so that their class should perform better in the test. Teachers are normally more co-operative with researchers when their own skills and attitudes are not the topic of the study.

6. RESULTS

In reporting results, the multivariate repeated measures analysis has been used. By means of this method (cf. Bock 1967, 85-103; Stevens 1986, 402-453) the long-term effects are estimated either at three different times: pre-test (T_0), post-test (T_1) and delayed post-test (T_2); or on two different occasions T_1 and T_2 (MGLH Fully factorial (M)ANOVA; Wilkison, Leland. SYSTAT 1989, 180-277).

Repeated measures analysis establishes the main trend and the statistical significance of the results.

However, results and differences between the groups are analysed separately for each time (T_0, T_1, T_2) by a t-test.

6.1. Common Intrinsic and Instrumental Motivation: Homogeneity Between the Groups (T_0)

The pupils were tested three months (T_0) before the treatment to ensure that the groups were homogeneous.

There were no statistically significant (.05) differences in common intrinsic motivation between the groups (p= .890, .705 and .587; see error bars in figure 6.A.).

Nor were there any statistically significant (.05) differences in common instrumental motivation between the groups (p= .650, .498, .284; see error bars in figure 6.B.).

No link was found either between sex and motivation, or between school success and motivation at T_0.

Summary: The groups I, II and III were found to be similar enough to be used in the experiment.

Treatment: Intrinsic motivation (group I) and instrumental motivation (group II) were produced by the different treatments (as described in ch. 5.3.) before the exhibition visit. Group III without the treatment was assumed to have situation motivation caused purely by the exhibition experience.

The total number of subjects is 130 (N): Intrinsic treatment (N:46), instrumental treatment (N:45), and situation treatment (N:39).

6.2. Intrinsic Motivation

6.2.1. Intrinsic Motivation: Treatment Effect (T_1)

The relation between treatment and intrinsic motivation measurement is shown in the next table:

Table 6.1. Treatment and intrinsic motivation.

REPEATED MEASURES ANALYSIS N:130

Dependent variable: Intrinsic motivation
T_0 T_1 T_2

Test for effect called: Motivation treatment

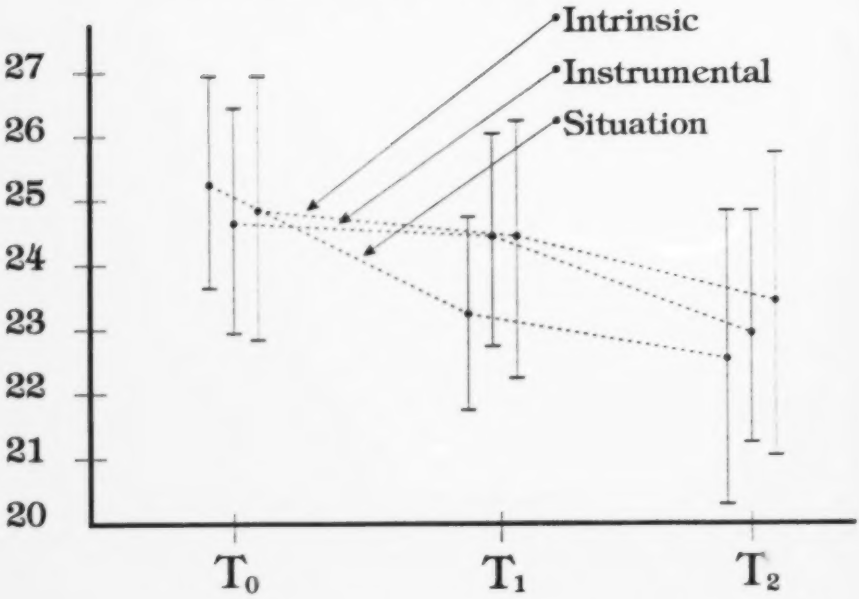
Between subjects

Source	SS	DF	MS	F	P
Treatment	16.938	2	8.649	0.188	0.829
Error	5709.752	127	44.959		

Thus, there is no statistically significant relation between the different treatments and the results of the pre-test, post-test and delayed post-test for intrinsic motivation.

The results for the different treatment groups at T_0, T_1, and T_2 are shown in the next figure.

Figure 6.A. Intrinsic Motivation: differences between the treatment groups (.05 error bars).*



The intrinsic motivation of the two treatment groups ("Intrinsic motivation" and "Instrumental motivation") is practically the same after the treatment. Their difference from the "Situation motivation" group is, however, not statistically significant.

*The line connecting the error bars T0, T1, and T2 does not indicate an actual change in results during the time, but makes it easier to understand the trends of the results.

6.2.2. Intrinsic Motivation: Constancy (T_2)

The effect of intrinsic treatment can still be seen, and the difference between the "Intrinsic motivation group" and "Instrumental motivation group" increases after six months. Again, the situation motivation group has the lowest scores. However, the differences are not statistically significant: the intrinsic motivation treatment did not have strong long-term effects (see Figure 6.A.).

6.3. Instrumental Motivation

6.3.1. Instrumental Motivation: Treatment Effect (T_1)

The relation between the treatment and the instrumental motivation measurement is shown in the next table:

Table 6.2. Treatment and instrumental motivation.

REPEATED MEASURES ANALYSIS N:130

Dependent variable: Instrumental motivation

T_0 T_1 T_2

Test for effect called: Motivation treatment

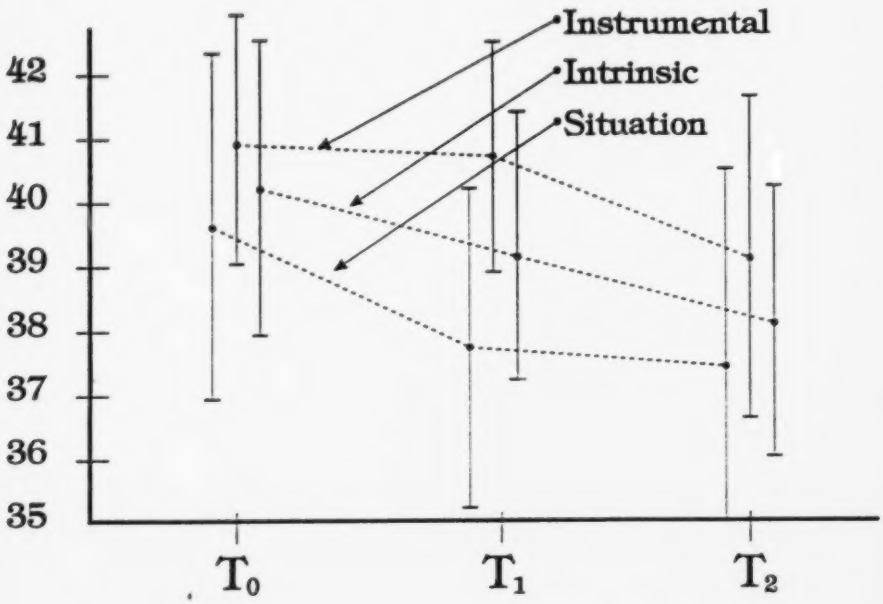
Between subjects

Source	SS	DF	MS	F	P
Treatment	255.334	2	127.667	2.195	0.116
Error	7387.231	127	58.167		

Thus, there is a much stronger relation (here, than in 6.1.) between treatment and results in the pre-test, post test and delayed post-test for instrumental motivation. However, the treatment effect is not statistically significant.

The results at T_0, T_1, and T_2 show differences developing between the groups (see figure 6.B).

Figure 6.B. Instrumental Motivation: differences between the treatment groups (.05 error bars).



After the treatment, the "Instrumental motivation group" is on its own level compared with the other groups (see figure 6.B): the difference from the "Situation group" is statistically significant (.05), but the difference from the "Intrinsic group" (p: .014) is not significant.

6.3.2. **Instrumental Motivation: Constancy (T_2)**

Hypothesis 4c: Instrumental motivation is not long-lasting.

Instrumental motivation is also stronger in the treatment group six months later (see figure 6.B.), but the differences between the groups are no longer statistically significant.

The results support the hypothesis.

6.4. Situation Motivation

6.4.1. Situation Motivation: The Exhibition Experience (T_1)

Situation motivation is measured in the context of the exhibition experience. Therefore, there are no data from the time before visit (i.e. T_0).

The relation between treatment and situation motivation measurement is shown in the next table:

Table 6.3. Treatment and situation motivation.

REPEATED MEASURES ANALYSIS N:130

Dependent variable: Situation motivation
T_1 T_2

Test for effect called: Situation/Exhibition treatment
Between subjects

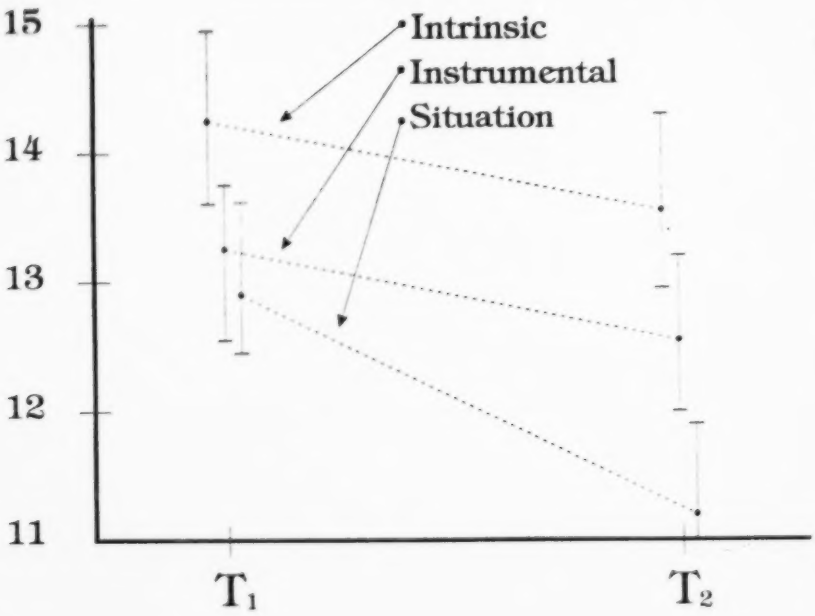
Source	SS	DF	MS	F	P
Treatment	162.021	2	81.011	10.553	0.001 ***
Error	974.963	127	7.677		

Thus, the groups have different situation motivation towards the exhibition visit and the difference is statistically very significant (.001). This indicates that the effect of the treatment has been strong.

Hypothesis 4a: The intrinsic motivation group is more positively motivated towards the science exhibition than other groups.

The results of the test at times T_1 and T_2 are presented in Figure 6.C.

Figure 6.C. Situation Motivation: differences between the treatment groups (.05 error bars).



The figure shows that the intrinsic motivation group has the strongest motivation. The difference between it and other groups is statistically significant (.05).

The instrumental motivation group has stronger motivation than the situation motivation group, but the difference is not statistically significant.

6.4.2. Situation Motivation: Constancy of The Exhibition Experience (T_2)

Hypothesis 4b: Intrinsic motivation is longer-lasting than instrumental or situation motivation.

Positive motivation towards the exhibition became weaker after six months for all the groups (see Figure 6.C.). The motivational groups remain ranked in the same order, but the differences between them increase and are statistically significant (.05).

All these results support the hypothesis.

6.5. School Success and Motivation

Is there also a relation between school success and positive situation motivation towards the exhibition?

Repeated measures analysis shows that there is no statistically significant relation between school success and common intrinsic (repeated measures p-value = .275) or common instrumental motivation (p: .562).

However, situation motivation ("exhibition experience"), is related to school success in all the treatment groups (repeated measures p-value: .027). The test shows that pupils performing well at school have a more positive exhibition experience. This effect is statistically significant (.05) in all the treatment groups.

6.6. Sex and Motivation

In motivation studies the differences between females and males are often studied. Here, no theoretically derived hypothesis was made. Nevertheless, the relation between sex and motivation test scores was examined.

No statistically significant relation between sex and motivation scores was found in any of the tests. Repeated measures p-values are as follows: Common intrinsic motivation (.326), Common instrumental motivation (.451), and Situation motivation (.712).

Other repated measures analyses were made, where sex was chosen as a covariance. No statistically significant relation between sex and motivation was found in these tests either.

Thus, motivation towards the exhibition is very much the same for girls and boys.

6.7. Learning and Motivation

6.7.1. Learning Entities: The Entity Test

The relation between motivation treatment and the learning of entities (i.e. concepts; see 3.5.) is shown in the next table:

Table 6.4. Motivation treatment and learning entities.

REPEATED MEASURES ANALYSIS N:130

Dependent variable: Learning entities
T_1 T_2

Test for effect called: Motivation treatment

Between subjects

Source	SS	DF	MS	F	P
Treatment	2.991	2	1.495	3.223	.043 (*)
Error	58.927	127	0.464		

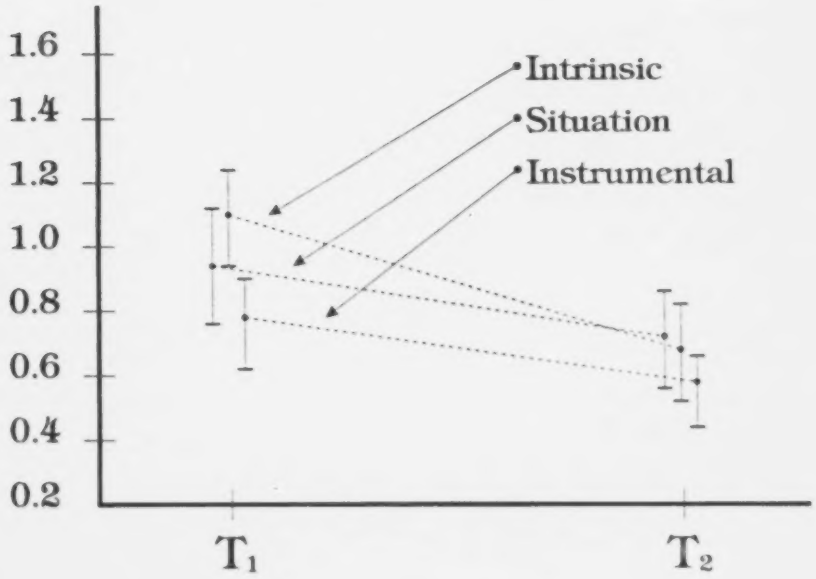
The test shows a statistically significant (.05) relation between the different motivational groups and their results in both the post-test and delayed post-tests (designed to measure the learning of entities). The results indicate that the treatment was effective. The data are analysed below, looking in more detail at differences between the motivational groups.

Hypothesis 3a: School classes with intrinsic motivation learn entities better than classes having instrumental or situation motivation.

The results for different motivation treatment groups are shown in the Figure 6.D (page 140).

Figure 6.D. shows that the intrinsic motivation group performed best in the test. The difference between it and the instrumental motivation group was statistically significant (.05). However, the difference between the intrinsic motivation and situation motivation groups was not statistically significant.

Figure 6.D. Entity Test: differences between the treatment groups (.05 error bars).



6.7.2. Learning Entities: The Essay Test

The theme of the guided tour round the exhibition was "Blood circulation". The information given in different parts of the exhibition was linked to this entity.

In the Essay Test the topic was "The role of blood circulation". This test tells how well the pupils learned the main concept of the exhibition.

Table 6.5. Motivation treatment and learning entities - The Essay Test.

REPEATED MEASURES ANALYSIS N:130

Dependent variable: Learning entities: The Essay test
T_1 T_2

Test for effect called: Motivation treatment

Between subjects

Source	SS	DF	MS	F	P
Treatment	41.227	2	20.613	11.113	0.001 (***)
Error	239.270	127	1.855		

Thus, there is a very significant (.001) statistical relation between different motivation treatments and the groups' results in both the post-test and delayed post-test (in which the Essay Test is designed to measure the learning of entities). The effect of motivation treatment is strong.

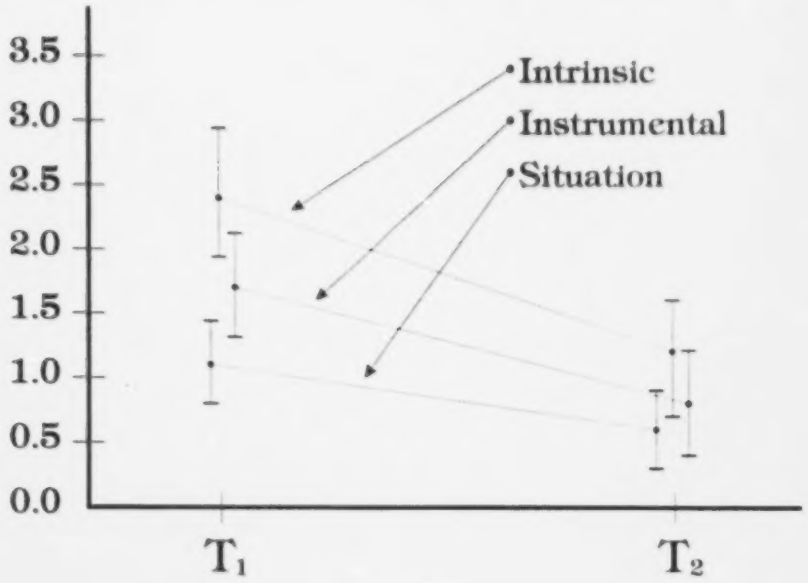
This result firmly supports the main hypothesis of the study. The data for different motivational groups are now analysed.

Hypothesis 3a: School classes with intrinsic motivation learn entities better than classes having instrumental or situation motivation.

The results for different motivation groups are shown in the next figure (page 141).

Figure 6.E. shows that the intrinsic motivation group performed best in the test. The difference was statistically significant (.05) between it and the instrumental and situation motivation groups.

Figure 6.E. Entity Essay Test: differences between the treatment groups (.05 error bars).



6.7.3. Learning Entities: The Constancy Of Results

Hypothesis 3c: Constancy of learning is longer-lasting for the intrinsic motivation group than for the other motivation groups.

The Entity Essay Test supported Hypothesis 3c (see figure 6.E.): the intrinsic motivation group was best able to re-produce the Blood Circulation entity. The difference between the intrinsic and instrumental motivation groups was statistically significant (.05), but there was no significant difference between the intrinsic and situation motivation groups.

The Entity Test (see Figure 6.D.) does not support the hypothesis. The intrinsic motivation group forgot even more than the other groups. But it is also a matter of a 'low scores dilemma' - the scores of the other groups cannot drop in the same proportion, i.e. "below zero" (cf. Lord 1967; Harris 1967).

Surprisingly, the situation motivation group performed best in this delayed post-test, but the difference was not statistically significant compared with the intrinsic motivation group. The hypothesis is supported by the fact that the instrumental motivation group also scored lowest in the delayed post-test, and the difference between it and other groups was statistically significant (.05).

6.7.4. Learning Isolated Facts

In the knowledge test, six items measured knowledge of isolated facts which could be learned only by rote. These items could be answered using information from the exhibition. The pre-lessons did not give any direct information concerning them.

Table 6.6. Motivation and learning isolated facts.

REPEATED MEASURES ANALYSIS N:130

Dependent variable:

Learning isolated facts

T_1 T_2

Test for effect called: Motivation treatment

Between subjects

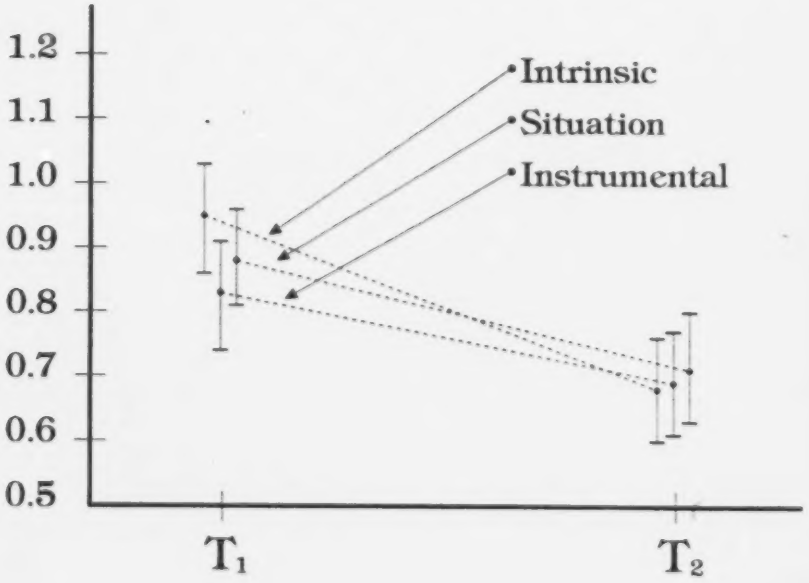
Source	SS	DF	MS	F	P
Treatment	0.188	2	0.233	1.981	**0.142**
Error	14.931	127	0.118		

Thus, there is no statistically significant relation between motivation treatment and pupils' learning of isolated facts. The effect of the treatment was weak. However, deeper analysis of different motivation groups will show other differences (see below).

Hypothesis 3b: School classes with instrumental motivation learn isolated facts better than other groups.

The results for different motivation groups are shown in the next figure.

Figure 6.F. Isolated Facts Test: differences between the treatment groups (.05 error bars).



The results contradict the hypothesis (see figure 6.F.). The intrinsic motivation group also performed best in this test. There is a statistically significant (.05) difference between intrinsic and instrumental motivation groups, but not between intrinsic and situation motivation groups.

6.7.5. Learning Isolated Facts: The Constancy Of Results

Hypothesis 3c: Constancy of learning is longer-lasting for the intrinsic motivation group than for the other motivation groups.

The hypothesis receives no support. All groups forgot many isolated facts in six months. There are no statistically significant differences between the levels of knowledge of the groups (see figure 6.F.).

The intrinsic motivation group forgot most isolated facts and the situation motivation group remembered them best. However, the difference is not statistically significant.

6.8. Pre-lesson and Exhibition Learning

The intrinsic and instrumental motivation groups had one (45 minute long) pre-lesson before visiting the exhibition. During the lesson some facts of human biology, connected with the topics of the exhibition, were repeated and taught.

The situation motivation group did not have a pre-lesson.

Table 6.7. Pre-lesson and exhibition learning.

REPEATED MEASURES ANALYSIS N:130
Dependent variable:
Learning Pre-Lesson Facts
T_1 T_2

Test for effect called: Lesson/No-lesson
Between subjects

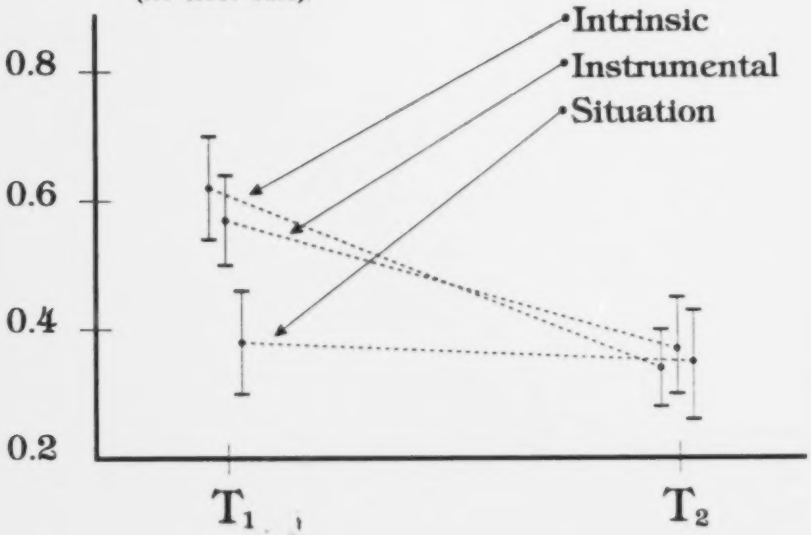
Source	SS	DF	MS	F	P
Treatment	0.505	2	0.252	3.319	0.039 *
Error	9.502	127	0.076		

The test shows that pre-lesson treatment had a statistically significant (.05) relation to the learning of these facts in the exhibition.

Hypothesis 2: School classes that have a pre-lesson before a visit to a science exhibition gain cognitive advantage, and learn better than other groups having no pre-lesson.

The knowledge test contains items that measure the facts taught both in the pre-lesson and in the exhibition. The results are shown in the next figure:

Figure 6.G. Pre-lesson Test: differences between the treatment groups (.05 error bars).



The figure 6.G. shows the effect of the pre-lessons. The difference is statistically significant (.05) between the group that had no pre-lesson, and those whose learning in the exhibition was supported by the content of a pre-lesson.

Six months later there is no statistically significant difference between the groups.

6.9. School Success and Learning in the Exhibition

What is the role of the pupils' school success as a background variable in the process of learning in the exhibition? As an indicator of school success, the mean of the academic subjects on a school report ("lukuaineet") is used (Salmi 1992a).

Repeated measures analysis shows that the relation between school success and learning is statistically very significant, both in the post-tests (T_1) and in the delayed post-tests (T_2).

P-values are as follows: Learning entities test (.001), learning isolated facts test (.001), and advantage from pre-lessons test (.002).

School success plays a dominant role (as a background variable) in the learning process in the exhibition.

6.10. Sex and Learning Results

It is noticeable in Finland that, at the age of 12-15 years, girls succeed better in school than boys . This difference is also typical of the subjects of this study: girls average better school grades in academic subjects ("lukuaineet": girls 8.09; boys 7.51) than boys. As measured by a t-test, the difference is statistically very significant (p= .001).

The difference between boys and girls is very small in all the cognitive tests of this study (Entities; Isolated facts; and Pre-Lessons). Although the girls performed slightly better in all the cognitive tests (except in the Entity Test (T_1)), the differences are not statistically significant.

7. ANALYSIS

The main result of this study is that the different background and different quality of motivation of school classes has an important relation both to the learning results in the exhibition and to the pupils' motivation towards the exhibition. These results support the main hypothesis of the study.

Main Hypothesis: The intrinsic motivation group is deep-learning oriented, whereas the instrumental motivation and situation motivation groups are surface learning oriented.

The first analysis in this chapter is made on the basis of the results of the motivation tests, in order to find out whether the groups have different motivation after the treatment and after their visit to the exhibition.

Secondly, the learning results are analysed to find the differences and similarities between the motivation groups after the alternative treatments.

7.1. Motivation Treatment

The groups I, II and III were homogenous in terms of common intrinsic and instrumental motivation before their treatment and experiment.

The intrinsic motivation treatment did not succeed completely. The difference compared with other groups after the treatment was not statistically significant when it was measured by the common intrinsic motivation test.

There are several reasons for this. By definition, it is not possible to create intrinsic motivation quickly and peer pressure and classroom atmosphere both influence the creation of intrinsic motivation.

The instrumental motivation treatment succeeded - surprisingly well. This group reacted strongly to the reward/punishment motivation. The effect of the treatment can be seen clearly in the common instrumental motivation test.

The situation motivation treatment seemed to succeed. The idea was that the science exhibition an sich creates situation motivation. Situation motivation appeared especially in the long-term results, although all three types of motivation were reduced in the long term.

7.2. Situation Motivation: The Exhibition Experience

The exhibition visit was a positive experience for all the pupils, but some distinct differences were found between the motivation treatment groups.

The intrinsic group was eager to learn, wanted to stay longer at the exhibition, had fun and considered the exhibition visit as educational and useful. This result supports the motivation hypothesis 4a.

According to the hypotheses, the instrumental group would have a weak motivation towards the exhibition. Although their visit would affect their marks in a school grade test, they liked the exhibition more than the situation group, whose motivation was short-lasting, depended on external factors and was merely the effect of escaping from daily routine.

The exhibition visit is very strictly divided in the pupils' minds into the time-tabled period and their own "free time" period. According to theory, freedom to explore is an essential feature of the learning process in an exhibition, as discussed in chapter 2. Therefore, the motivation test included one item measuring the pupils' feelings towards the "free time" period they spent in the exhibition.

There is a very clear difference between the motivation groups in their opinions of their "free time" periods: the situation group was nearly satisfied, the instrumental group wanted to have a little bit longer, and the intrinsic group wanted to have a much longer "free time" period. These results agree very well with the theoretical background of the study. The situation motivation group enjoyed the visit, but did not want to stay there any longer. The instrumental motivation group wanted to have a little bit longer period on their own: according to the theory, they wanted to study more for their school grade test. The intrinsic motivation group would have liked to spend a much longer time at the exhibition.

The constancy of the results in the motivation test support hypotheses 4a and 4b. The intrinsic group also had the strongest and most long-lasting motivation in the delayed post-test (see 6.5.).

This indicates that it is possible to find long-lasting positive motivation effects linked to the learning process, and that other kinds of motivation treatment do produce less positive and shorter-lived results.

It also became evident that the exhibition experience is so effective that it must have enhanced the pre-motivation treatment.

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As a whole, the results of the motivation test confirm the existence of different motivation qualities in the groups and demonstrates the success of the different pre-treatments.

7.3. Learning Entities

The most important result turned out to be the process of learning entities (i.e. concepts, see chapter 3.5.): the intrinsic motivation treatment group learned best.

According to theory, the constancy of the entity learning results should also have been better in the intrinsic motivation group than in the other groups, but the results did not support the hypothesis. However, the data for the most powerful entity item "Blood circulation", support both the entity learning hypothesis and the constancy of learning results hypothesis.

The instrumental motivation group did not learn entities well. This result was predicted by the theory, but it is interesting that their scores were very much lower than those of the situation-motivation group.

The good results of the situation motivation group in the entity tests are interesting. According to theory and to the hypotheses, their learning should have been more oriented to external features and they should also have forgotten what they had learned more quickly. However, this was not the case. There must be several factors contributing to this, but this study gives only indirect answers. It even suggests that the theory and definition of situation motivation should be changed (as discussed in chapter 9).

7.4. Learning Isolated Facts

The relation between motivation treatment and the results of the isolated facts test is far less strong than that between motivation treatment and the results of the entity test. Differences were smaller and the treatment effect vanished after six months. The results of the isolated facts test are also in many ways contrary to the hypothesis.

The intrinsic motivation group learned isolated facts best. One obvious reason for this is that the intrinsic motivation group was able to link the isolated facts to the theme - the main 'entity' (concept) of the guided tour - blood circulation. However, they did not remember isolated facts better than others after six months.

The instrumental motivation group remembered isolated facts worst in both tests (T_1;T_2). An obvious reason for this might be that the pupils were unable to learn and remember isolated facts in their usual way, by rote, in the exhibition setting, as compared to school conditions.

The situation-motivation group performed surprisingly well in the isolated facts test.

These results indicate that the exhibition itself had such a strong effect on pupils that the motivation differences disappear, at first, due to this external effect. This result accords with theory and with other results concerning out-of-school learning settings (see 2.10.; 1.4.).

7.5. The Pre-lesson

The study shows the beneficial effect of cognitive preparation for the exhibition visit. The groups that had a pre-lesson, when they were taught facts concerning human biology and some facts from the exhibition, performed much better in the knowledge test.

This result was to be expected. It had previously been demonstrated in many studies concerning learning in informal settings like science centres, museums and field trips (cf. Melton, Feldman & Mason 1936; Davis & Kimche 1976; Falk, Martin & Balling 1978; Gennaro 1981).

This result is also not surprising in light of our basic knowledge of learning and teaching: if something is taught in two alternative ways, it is more effective than if it has been taught only once without repetition.

However, no so-called 'transfer effect' was found in relation to the pre-lesson. The pre-lesson only conferred a learning advantage on those facts that had been taught in the pre-lesson and were then repeated during the guided tour.

7.6. School Success

In line with the original study design, school success was examined only as a control variable, and no pre-hypotheses concerning the relation between learning, motivation and school success were made.

School success did not play an important role in the pupils' common intrinsic or instrumental motivation in any of the tests (T_0, T_1, T_2). However, the results

show a strong link between both (a) school success and learning, and (b) school success and positive motivation towards the exhibition.

School success is an important factor in all the cognitive tests: learning of entities, learning of isolated facts and learning of facts introduced in the pre-lesson. The relation between school success and situation motivation is also clear. The treatment to induce different kinds of motivation did not change the relation between the pupils' school success and their learning results. In the delayed post-test, the relations between school success, learning results and situation motivation towards the exhibition are even more evident.

7.7. Sex

In a normal school test situation girls perform much better than boys at this age. In the sample of this study too the girls clearly had better school reports. However, there are no significant differences between the sexes in the learning results from the exhibition.

There are no significant differences between girls and boys in their common intrinsic, common instrumental, or situation motivation towards the exhibition. Girls liked the exhibition, too. In fact, their motivation towards the exhibition had become more positive after six months.

An informal learning setting like a science centre may have features that help boys to learn better than under normal classroom conditions. There is no formal discipline and learning is based on the pupils' own activity. The technical equipment might have interested the boys more than the girls.

7.8. Chain Reaction

Two interesting phenomena were observed regarding the intrinsic motivation treatment (see 5.3.):

1. The intrinsic motivation treatment group achieved the best learning results.

2. Their motivation towards the exhibition visit was higher than the motivation of the other groups immediately after the visit and remained so after six months.

Although the treatment to induce intrinsic motivation did not have a transfer effect on the common intrinsic motivation of the pupils, it strongly affected the pupils' positive motivation towards the science exhibition visit. It therefore seems evident that the positive motivation towards the science exhibition visit caused the improved learning results. This cause-and-effect chain seems real, but further analysis is needed.

The chain reaction can be seen in all the results due to the form in which the study was designed: the treatment effect (intrinsic/instrumental) was measured after the exhibition visit, i.e. the manipulation included both the treatment and the exhibition experience (see Table 5.1. Design of the study).

8. VALIDITY AND RELIABILITY

8.1. Validity

The use of repeated measures analysis gave many advantages, but has attendant problems too (cf. Taipale 1984, 17-20). The most important characteristic of the test is its capacity to analyse, in a single test, the dependent variables on three occasions: in pre-tests (T_0), post-tests (T_1), and delayed post-tests (T_2).

The design of this study is classified as a quasi-experiment (cf. Campbell & Stanley 1963; Cook & Campbell 1979; Glass 1988). The typical concerns regarding internal validity in such studies have been listed. The list ("Threats to internal validity" by Cook & Campbell 1979) is applied here to evaluate the validity of this study:

History and maturation: 1. Pupils did not know about the forth-coming exhibition visit and tests, when the pre-test was given three months before the visit. 2. The results of the post-test and delayed post-test could have been influenced, but all the groups performed better in the post-test than in the delayed post-test; i.e. "growing older, wiser and more experienced" did not influence the results. 3. The delayed post-test took place six months after the exhibition visit. This is a long time - and even longer in the time perspective of 13-year-old pupils. This presents some challenges to the validity of the study.

Normally a pupil would not remember a two-hour school lesson six months later unless something extraordinary, like a party, play or sports competition, had taken place. However, the pupils remembered their visit to the exhibition well.

Therefore, the results of the delayed post-test must be interpreted very carefully. In the knowledge test, several intervening variables cannot be controlled. The motivation test may be more valid. "Image" is the best word to describe the pupils' feelings for the exhibition after six months, in the sense that they retain strong impressions of their visit and that it was a memorable (and for the most part positive) experience in their lives.

The treatment for inducing instrumental motivation, i.e. giving a test which would affect the next school report, was no longer valid by the time of the delayed post-test six months after the visit. However, the results from the delayed post-test indicate the constancy of the treatment for instrumental motivation.

One of the elements that might have affected the subjects is their "test-conciousness". Kuhl & Stahl (1986) studied the validity of motivation study questionnaire scores and, in particular, how the subjects' answers are affected by the degree to which they are aware of the personality attribute assessed by the test. Here, it is possible that the intrinsic motivation group gave more motivated opinions, because their treatment clearly emphasised the "feed-back" nature of their answers.

Selection "is pervasive in quasi-experimental research, which is defined in terms of different groups receiving different treatments as opposed to probabilistically equivalent groups receiving treatments in the randomised experiment (Cook & Campbell 1979, 53)". As reported, the six classes were chosen at random from the schools in the greater Helsinki area. The socio-economic background of the school districts was not analysed, for two reasons: 1. A socio-economic effect is not probable according to motivation theory. 2. In several schools, the pupils

came from a large area consisting of different environments and socio-economic bagkgrounds (cf. Scheinin 1990, 112-114).

Mortality: Non-response of subjects and loss of data reduce validity. The main difficulty in using the repeated measures analysis is its sensitivity to non-response. The test disqualifies subjects with missing data: a subject lost in one test is also excluded from the other test.

The original sample size, N, was 168 in the pre-test (T_0). Eight subjects were missing from the post-test (T_1). Thirty (30) more subjects were missing from the delayed post-test (T_2). So the final value for N is 130 subjects.

A certain amount of information was lost, but did not affect the results adversely. This was ensured by applying a separate t-test to all the groups (with different N) at times T_0, T_1 and T_2. The differences (p-values) between the groups varied, but remained at the same level of statistical significance.

Systematic reasons for non-response could not be found. The average school grade in the non-response group was lower, but the difference was not statistically significant. An 'attrition effect', which is the typical reason for non-response, could not be found: the reasons for absence from the test were those of everyday life, such as being ill or moving to another school.

In one case (school E), six pupils missed the delayed post-test because of a careless mistake in administrative arrangements. However, a new test was not arranged for them because of the strong likelihood of a test effect (the opportunity of getting hints - right or wrong answers from school mates). The

pupils who had moved to other schools were not tested, separately, because social context was considered essential to the study.

Compensatory Rivalry by Respondents Receiving Less Desirable Treatments is a typical threat to internal validity. In one case, signs of this can be observed: school F performed better than the other situation motivation school (E). It had been emphasised to the teachers that the study does not measure the quality of either schools or teachers. However, it is possible that the spirit of rivalry affected the teacher, wanting to show that her class could perform as well as the others - without pre-lessons. This is not pure speculation, because the encoder of the study reported that pupils in different classes gave near-identical answers to some questions. The exceptionally positive attitude of the situation motivation group from school F was also reported by another teacher in an informal discussion.

Randomisation is not possible in quasi-experiments (see 'Selection' above). However, the quasi-experimental approach is the only appropriate approach for this topic of research. It is therefore made as valid as possible - without complete randomisation - by attempting to control the threats to validity and then to rule them out (Cook & Campbell 1979).

Causality: It must be noted that correlation does not indicate cause and effect, but only the connection between two effects. In this study, the relation between different kinds of motivation (situation, instrumental, intrinsic), and learning results, are based on motivation theory and on other data indicating the relation between these two. However, the exceptional success of the situation motivation groups - better than the hypothesis suggested - forces us to use the terminology of causality particularly carefully.

It seems that the instrumental treatment (i.e. giving pupils the opportunity to improve the biology grade in their school report) succeeded. This is related to the traditional question of success-orientation vs. fear-of-failure orientation in motivation studies (Kuhl & Stahl 1986).

8.2. Reliability

Reliability of measures

Reliability is measured as "true" changes among the subjects after the treatment. Reliability is often determined by 'stability' or 'test-retest' (Cook & Campbell 1979, 43). However, the test-retest method could not be applied in this study because of the possibility of the subjects learning from the test.

This study is based on repeated measures analysis with pre-tests, post-tests and delayed post-tests. The role of 'stability' is different in repeated measures analysis - 'change' is the subject of the study (Glass 1988, 447-454). The only way of assuring this kind of reliability is by conducting the complete study again, with new pupils. This is recommended as a topic for further research, in formal education settings as well as out-of-school settings.

The use of longer tests is often recommended as a method for increasing reliability (Cook & Campbell 1979, 43-44). However, in this study each subject had to complete several forms and the number of items could not be increased without danger of tiring or frustrating the pupils.

A group mean is more stable than individual scores. Therefore "using more aggregated units, e.g. groups instead of individuals (ibid.)" is recommended as

a way of ensuring reliability. Testing groups instead of individuals is the main approach in this study. However, there is one danger: at this age (12-13 years) pupils are very heterogeneous in their cognitive development (Hautamäki 1984) and group testing may not reveal these individual differences. On the other hand, the normal characteristics of statistical analysis (mean, variance, standard deviation, etc.) reveal them and make it possible to control the effect of individual differences.

Test item reliability

Reliability was estimated theoretically and measured by Cronbach's alphas. The Kuder-Richardson formula KR20 applies to the pre-lesson test, which has only 1/0 scores. In other tests, the alpha Coefficient is used. (Cronbach 1964).

Table 8.1. Reliability of the tests.

	T_0	T_1	T_2
Intrinsic motivation test	0.75	0.73	0.76
Instrumental motivation test	0.52	0.52	0.64
Situation motivation test		0.59	0.47
Pre-lesson learning test		0.71	0.40
Isolated facts learning test		0.53	0.68
Entity learning test		0.78	0.34

Using alpha coefficients, the internal consistency of the measuring instruments can be estimated. These 'indexes of homogeneity' are not high. This is often the case in motivation studies (Atkinson & Raynor & al. 1974, 48-51; Mustila 1990, 103-105).

However, the alpha coefficient for the most important motivation test of this study, the intrinsic motivation test, is high (.75; .73; .76) and stays at the same level in pre-test (T_0), post-test (T_1) and delayed post-test (T_2).

The alpha coefficients for instrumental motivation tests (.52; .52; .64) and situation motivation tests (.59; .47) also indicate reliability.

The reliability of the motivation tests remains at the same level throughout the process (T_0, T_1, T_2). This indicates that the measuring instrument can be recommended for use in other studies.
The most important cognitive test of this study, the Entity test, also has a high alpha coefficient (.79/T_1), but the coefficient falls in the delayed post-test.

The alpha coefficients do not, however, show too weak a reliability: the values of inter-item correlation of variances, for example in the pre-lesson test, are close to optimum (0.23 - 0.25), but the number of items (N:6) is so small that the alpha coefficient cannot be higher. As stated above, the number of items could not be increased because the pupils would have got too tired.

Reliability of the delayed post-test is much weaker, the only exception being the Isolated Facts test. This confirms the previous statements concerning validity of the delayed post-test (discussed above).

Intrinsic motivation test: seven items originally developed by Vepsäläinen (1980) were applied. The theoretical background to Vepsäläinen's motivation test is similar to that of this study. Although Vepsäläinen placed greater emphasis on conflict theory (Rosenfelt), the seven items were appropriate to this study. The

opportunity of applying the same test in two studies occurs all too rarely in educational science.

Instrumental motivation test: twelve items originally developed by Vepsäläinen (1980) were applied.

The original test by Vepsäläinen contained 33 items of which only 7 were found appropriate to the intrinsic motivation test, and 12 to the instrumental motivation test. Items were chosen on the basis of theoretical definitions of intrinsic and instrumental motivation (see 3.7.).

Situation motivation test: in the situation motivation test ('Exhibition experience'), two items (nos. 5 and 6) were rejected because of their inability to discriminate. The differences between the groups remained the same even though these two items were left out. However, the pupils' positive answers to item 6 confirm their satisfaction with the guided tour. Such items may be useful in other studies, because the role of the guide (item 6) and the relevance to the school report (item 5) can be critical in other out-of-school learning situations.

Two further items that applied the ordinal scale were rejected. Pupils were asked to rank six statements concerning the nature of the exhibition in order of preference. The statements were originally intended to measure the pupils' motivation quality (intrinsic, instrumental, situation). However, the statements described the exhibition in far too concrete and practical terms, and so had to be discounted. Furthermore, their ability to separate the different groups was poor, and the ranked scale could not be connected with other items (sum scores) in a valid way.

Four open-ended questions and two multiple-choice items about the exhibition were also included, to provide practical feed-back that the planners could use, e.g. for science centre development.

Knowledge tests:

Pre-lesson test results showed a clear difference between those groups which had a pre-lesson and those which did not. This also supports the inner validity of the test.

Isolated facts test results showed the smallest differences between the groups. However, this is not a problem of reliability, but demonstrates features of exhibition learning.

The entity test had two parts: The Entity Test and The Essay Test. Blood circulation was the main theme of the exhibition visit - and maybe also the most concrete one for the pupils. The other items in The Entity test measured sub-themes of the exhibition. The results from The Essay Test are more reliable than those from The Entity Test.

Julkunen (1989) observed that open tasks cause more failures than closed tasks, with the exception of the cooperative learning method.

The Reliability of Treatment Implementation

The guided tours in the exhibition were evaluated by three methods: the guide's own report, follow-up by an observer, and mini-cassette recordings from the

pocket of the guide. Recordings were not a success, and have only curiosity value (see 5.4.5.).

Personal reports show that the relationship between the school groups and the guide was positive and open. This was also the observer's impression.

Observations and personal reports show that the guided tours (after pre-training with other groups) succeeded in keeping to the original plan and time table. However, one misunderstanding occurred. School group B (intrinsic motivation) arrived at the exhibition twenty minutes too early and did not meet the right guide, but started to tour the exhibition with another guide, following another programme and route for twenty minutes before the mistake was discovered. Therefore, school B missed two sections of the exhibition and got information about the third in a slightly different way; the whole tour was shorter as well. The test scores from questions on the missed sections were weak compared with those of other groups. However, the data were included, although they are not totally valid. Stronger test scores would make those of the whole intrinsic motivation group correspondingly even stronger, and would support the hypothesis.

Pre-lesson treatment was given to all classes (A,B,C,D) by the same person. The lessons all followed the same outline, and no problems were reported. However, there are two essential questions of validity:

1. Was the school grade test treatment strong enough? This is a very common way of creating (instrumental) motivation at school. On the basis of the results (see chapter 6), the treatment was very effective: the scores of the instrumental treatment group were much higher than those of other groups.

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2. Intrinsic motivation is not easily created (Vepsäläinen 1980; Engeström 1984; Hedegaard 1986; see 3.4.). In this study, the principles of intrinsic conflict were applied (Hedegaard 1986; Engeström 1984; Vepsäläinen 1980). The weakness of the treatment is that the period allowed for inducing the intrinsic motivation was rather short (one lesson).

Most of the features of validity discussed above are matters of internal validity, although the relations between different types of validity are complicated and may sometimes be hidden. However, generalisation is the essence of both construct and external validity (Cook & Campbell 1979, 80-84).

Construct validity seems satisfactory in this study. It was possible to demonstrate the existence of different motivation types: intrinsic, instrumental and situation motivation. Before this study, the terms had only been used theoretically (cf. Engeström 1984) but, as the results of the study show, these terms can now be used more generally.

There are several so-called interaction problems with the construct validity (Cook & Campbell 1979, 80-84). One is discussed in more detail in the next chapter: how did the treatment affect the assumptions that the subjects made about how they were supposed to behave or to answer in the test? (cf. Kuhl & Stahl 1986, in 8.1; see also chapter 9: Discussion). However, there is no reason to suspect the honesty of the pupils' answers. Maybe negative feed-back was avoided, although they had no obvious reason for giving any particular type of answer.

External validity turns out to be more problematic: the results of the situation motivation group indicate problems with either the theory, treatment or measures. This indicates a need to develop the theory (see chapter 9: Discussion). A further

problem concerning external validity is the relevence of these results to formal learning settings.

8.3. Differences Within the Groups

Statistical tests did not show signs of the sub-groups distorting the results within the groups. However, this is a critical question of both validity and reliability, because each motivation group consisted of two different school classes.

Therefore the results of each class were also examined, for two important reasons: 1. The classes were homogeneous in terms of intrinsic and instrumental motivation (see 6.1.), but there might have been differences in their learning environments. 2. Although the visit to the exhibition was arranged in the same way for all classes, the basic nature of an exhibition visit is variable especially with respect to the pupil's "free time" period.

School Classes within the Motivation Treatment Groups

The best available way to compare classes with each other is by means of school grades ("lukuaineet").

The only statistically significant (.05) difference was between the highest and the lowest class mean: classes C and E. Other differences were not statistically significant.

The data for different school classes within the motivation groups are studied here only at a simple statistical level. The t-test is applied, and some interesting features can be observed.

Table 8.2. Difference between school classes within the different motivation groups (t-test).

	Intrinsic treatment		Instrumental treatment		Situation treatment	
	A vs. B		C vs. D		F vs. E	
Intrinsic motivation (T_0)	.977		.257		.134	
Intrinsic motivation (T_1)	.512		.024	**	.139	
Intrinsic motivation (T_2)	.823		.564		.412	
Instrumental motivation (T_0)	.022	**	.534		.201	
Instrumental motivation (T_1)	.312		.564		.405	
Instrumental motivation (T_2)	.011	**	.584		.412	
Situation motivation (T_1)	.328		.057		.001	***
Situation motivation (T_2)	.017	*	.074		.001	***
Entity Test (T_1)	.001	***	.547		.001	***
Entity Test (T_2)	.001	***	.458		.001	***
Isolated Facts (T_1)	.011	*	.308		.018	*
Isolated Facts (T_2)	.365		.652		.036	*
Pre-Lessons (T_1)	.001	*	.565		.001	***
Pre lessons (T_2)	.089		.203		.024	*

There were slight differences within the groups, i.e. between the classes, in common intrinsic and common instrumental motivation tests: Class B had stronger intrinsic motivation than A at T_0 and at T_2 (.01). Class C had stronger intrinsic motivation than D at T_1 (.01). Treatment, followed by the exhibition visit, seems to have opposite effects on the intrinsic and instrumental treatment groups: the differences between individuals in the instrumental treatment group grow, but become smaller in the intrinsic motivation group.

The t-test (table above) shows that the instrumental treatment group was the most homogeneous in all the tests. There were no statistically significant

differences between the school classes C & D in any of the knowledge tests and on only one occasion in the motivation tests.

In the situation motivation test, there were no big differences between A and B. However, six months later A liked the exhibition more than B (.05). The difference between F & E in the situation motivation test was statistically very significant: F liked the exhibition experience much more than E.

The intrinsic and situation treatment groups were clearly divided: in all the knowledge tests A performed better than B; and F better than E.

The difference between A & B and E & F was statistically very significant (.001) in the Entity Tests (T_1; T_2).

The difference was smallest, but statistically significant (.05), in the Isolated Facts Test (T_1). But the difference between A & B disappeared in the delayed post-test (T_2).

In the Pre-lesson test, A performed better than B and F better than E. In the post-test this difference was statistically very significant (.001), but in the delayed post-test the difference between A & B had vanished and was significant (.05) only between E & F. (Schools E & F did not have a pre-lesson; i.e. the tests measured their ability to learn isolated facts without a pre-lesson.)

Examination of the differences between school classes within the motivation groups shows the importance of learning environment to the classes, but in no way invalidates the mean results of the motivational groups.

9. DISCUSSION

The most important conclusion from this study is that different backgrounds and different kinds of motivation produce qualitatively different learning. This result might seem self-evident, but is not. The study strongly supports the theory of intrinsic and extrinsic motivation (see chapter 3: 3.7.).

Motivational pre-treatment of school classes about to visit the science centre exhibition succeeded. There were significant differences in the learning results between groups that did and did not receive pre-visit preparation in the classroom. The quality of motivation is the key factor in explaining the differences.

The distinction between types of motivation - intrinsic, instrumental and situation - is of course artificial and strict boundaries cannot be drawn between them. The same person exhibits a different type of motivation in different contexts, and even an isolated task can activate different types of the motivation in the same person. For example, a pupil may have liked the colourful exhibition and enjoyed the new computer programmes; she might have been interested in sleep research because of her nightmares last night; and she may try to gain a high grade in the next school test because her parents will then give her extra pocket money to reward her good results in school. One type of motivation is, however, often dominant in the learning process.

It might be supposed that it makes no difference what kind of motivation stimulates a pupil - the main thing is that pupils should learn and it is their own business under what mental conditions this happens. However, it is not irrelevant, because different types of motivation have clear links to different learning styles and strategies (see 3.5.)

Learning styles and strategies vary in efficiency and depend on pupils' individual abilities, habits and attitudes. Learning is a complex issue. To simplify matters, the broad terms - deep versus surface learning strategies - are used.

According to many theories, a deep learning strategy has some crucial advantages over a surface learning strategy. Intrinsic motivation is linked to deep learning strategies in many senses. It can be argued that intrinsic motivation is a pre-condition for deep learning, whilst instrumental and situation motivation lead very easily to surface learning (3.5.).

The results of this study support existing theories concerning learning strategies: the intrinsic motivation group learned concepts and entities best and had the longest-lasting motivation. They also learned isolated facts best, because they were able to link the isolated facts to a larger framework, i.e. blood circulation. The intrinsic motivation group also remembered what they had learnt longer.

The results related to learning strategies also indicate that it may be fruitful to apply Gardner's (1991) new model of the intuitive learner, traditional student and subject expert to further research into science centre learning.

Six months is a long period in the life of 13-year-old pupils. Six months is also a long period for the duration of educational research. There are innumerable, unidentifiable variables that may have affected the results in the delayed post-test carried out after half a year. Nevertheless, this test produced some interesting results.

In the normal school routine, pupils do not remember what happened during a casual two-hour-long lesson some months later. But they might remember something that happened in the school yard, or during a sports match against another school. In the same way, they remembered their visit to the science exhibition very well.

There is a clear distinction between the meaning of the words "remember" and "learn". If the objective is "learning" then it is useless to teach isolated facts without a meaningful context. And the context must be meaningful in two ways:

1. The topic must become relevant to the learner. The prerequisite for learning is a mental state close to "intrinsic conflict": the learner feels that there is a gap between her present abilities and the new skills and knowledge that are to be acquired. Learning is the process of stitching up the gap.

2. The learning process must be structured so that the learner can grasp a thorough understanding of the topic. Piaget's model of assimilation-adaption-equilibrium describes this process well. However, it must be emphasised that the "intrinsic conflict" is rarely solved entirely "inside the head". Solution of the mental conflict often demands a practical solution of the real-world conflict, and is achieved through the learner's activity (cf. 3.7.).

The demands for meaningfulness are a great challenge to teachers - and offer great opportunities to educators in informal settings. Only pupils themselves can tell what is meaningful, but their knowledge and experience are limited. Therefore, the skill to create exhibits that encourage open-ended exploration, and the talent to design interesting and logical learning processes, are the key elements in a good science exhibition.

Is it possible to create and stimulate motivation, its type and its strength? This study gives an affirmative answer, in the light of the motivation test and some cognitive learning results. However deeper analysis of this effect requires further research.

Situation motivation is activated when the external attractions are strong enough: new settings, strong stimuli, interesting people and social relations, humour, etc. All this and more is always available in any science centre. So this study shows without doubt that situation motivation is effective. Quite apart from being at the science centre,

the pupils were out of school: it is pleasant to leave the four walls of the classroom - whatever the alternative!

It is always possible to create instrumental motivation - whenever there is the promise of salaries high enough, or the threat of punishments unpleasant enough. In this study, the link between the forthcoming school test and its subsequent effect on the pupils' school report was (surprisingly) strong enough to create instrumental motivation.

This is also a way of motivating pupils under normal school conditions. A school test motivates all pupils. And the results of this study are typical of the effects of instrumental motivation. 'Normal' motivation towards the school test is also indicated by the fact that both school classes in the instrumental motivation group reacted in the same way: there were no significant differences between school classes C and D (see 8.3).

It is not possible to create intrinsic motivation by any external tricks; intrinsic motivation is acquired during the long period that a personality develops (see 3.4.-3.7.; 5.3.). The topic of the exhibition was medicine and human biology which is an interesting subject for pupils at the age of puberty.

The reason for post-testing the intrinsic group was explained to the pupils as follows: "The planners of the exhibition need feed-back from pupils just your age, so as to be able to develop better exhibitions for teenagers in the future". It was a strategy which appeals to pupils' real

interest in the topic, and tries to awake the "better I". However there is room for scepticism - can motivation be successfully created in this way? Although it was impossible to stimulate intrinsic motivation over a long period, the method described succeeded well in the light of the results of this study.

The school classes (A & B, C & D, E & F) in the three motivational groups achieved different results. This did not, however, cause serious problems of validity or reliability (8.1.-8.3.). However, the dissimilarity in results gives a clear indication of the importance of the learning environment in individual classes. This feature can also cause problems when planning school programmes in science centres: age, cognitive level and curriculum are the factors that are normally taken into account when planning the pre-visit materials, guided tours, tasks and school programmes in science centres, but the intrinsic social structure, learning environment of the class and teacher's role are also significant factors in the visit.

The question concerning the role of the pre-visit lessons was more or less a control question, because so many studies have already shown the benefit of pre-visit lessons for school classes (see 2.10.). The results of this study (see 6.2.; 7.3.) not only confirm the importance of preparing for a visit, but also make it questionable whether any educational visit should be made without first preparing for it.

The difference between girls and boys is one of the recurring questions of educational science. This study showed no significant differences

between the learning results or motivation of boys and girls. This is a significant result, because girls at this age both succeed much better in school and have a more positive attitude towards learning. The results of this study show that the practical, active and hands-on type of learning at science centres helps boys of this age (13 years) to learn. Another possible interpretation is that there is no real learning difference between boys and girls, and the disparities occur only under school conditions. The results also indicate that the development of these kinds of teaching methods must be continued.

One decision made about the methodology of this study is that the subjects are groups - classes, and not individuals - pupils. The main reason for this choice is the nature of visits by schools to science centres. The class is the basic unit of school, and a class is the basic unit for school visits to science centres. Therefore it is important to know whether classes can be effectively prepared, so as to improve the quality of their visit. And hence the study must be made at the group, and not individual, level.

Of course science centre visits are in many senses very individualised and free. The free "own time" period of the visit, in particular, is not directed and pupils follow their own inclinations. This aspect is a very interesting one, and a fruitful topic for future visitor studies. An open question is: how do ordinary visitors behave and learn in the exhibition, when their experience does not always match that envisioned by the exhibition planners and curators? (Salmi 1992b; Quin 1993).

The link between school success and cognitive learning from the exhibition is clear. The motivation of pupils who perform well in school is also stronger. This is a rather alarming result, because it feeds a vicious circle. Talented pupils learn more and poor pupils do not improve on their achievements. In one respect, however, this was not the case: boys who are less than average in school have average, or better, success in exhibition learning.

Science centres are planned following the hands-on principle, and the exhibitions are designed to interest all kinds of pupils and not only science-oriented pupils (see 2.10). Conflicts can therefore arise when carrying out an educational study: 1. this particular temporary exhibition was so knowledge-oriented that it demanded a firm basic understanding of human biology before visitors were able to learn from it, rather than simply enjoying the experience of their visit; 2. the tests were knowledge-oriented and therefore favoured talented pupils.

The word 'motivation' is very frequently used in every-day language and educational discussion. This reflects interest, and the importance that parents, teachers, administrators and researchers place on its effects. However, the definition of the word 'motivation' is imprecise. The results of this study suggested many new questions, and opportunities to focus carefully on motivation. The validity and reliability of the study appear good, and the intrinsic and instrumental assessments used here (Vepsäläinen 1980; applied) are therefore highly recommended in other studies concerning motivation. Repetition of this

study - in a formal education setting - might provide results valuable to both motivation theory and educational practice.

People learn increasingly from informal sources. During the last twenty years, most members of the general public have gained their environmental knowledge from the mass media. The skills for using computers have been learned at work, at home or via computer nets. Maybe the most dramatic example of the effectiveness of informal learning is the fact that most people in Tallinn, in the Estonian Republic, can understand and speak Finnish because during the nation's time of stagnation in the U.S.S.R. they were able to watch Finnish television, which became the preferred source of information and entertainment rather than Soviet television.

Science centres and exhibitions are another source of informal education. The clue to the educational role of a science centre is the circumstance of the visit: does the child come on her own (with parents, brothers and sisters, cousins, friends); or does she come as a pupil - a member of a school class?

The difference is remarkable. School classes do not come reluctantly to a science centre. It is always nice to get out of the classroom! But the motivational basis is different. The structure of the visit is often divided in three parts: guided tour, tasks and "free time". And the split between organised and free time is very clear in the pupils' minds.

A science centre is a learning laboratory in two senses: 1. It is a place where one can learn. 2. It is a place where learning can be studied and new methods developed. This study was conducted to gain information concerning school visits to science centres. Supporting the formal education system is the most visible role of these institutions, which are all the time linked to invisible, informal learning.

Motivational orientation has been studied theoretically, with support from some empirical data. The results show that the phenomena described by theory as "situation", "instrumental" and "intrinsic" motivation exist, but are not completely understood. The field is large and further research is needed. One important focus is the individual differences between pupils. Another relevant issue is the motivational orientation in "pure" informal learning, because the topic of this study is "out-of-school" learning as a link between formal and informal education. An important topic for study, and one which would provide practical help to teachers, would be a list of all the available opportunities for out-of-school learning in Finland. During the last decade informal education sources have started to be used as out-of-school complements to formal classroom teaching.

The exhibition itself has such a strong effect on pupils that it easily overshadows other motivational effects (for example pre-visit lessons). It may be concluded that the greatest benefit to be gained from a visit to a science centre (or from a similar informal-learning experience) is the change *f* in the visitor *f* of easily-aroused situation motivation into intrinsic motivation and deep-learning strategy.

This is rarely observed in the formal education system. On the contrary, a clear trend can be seen: in Finnish, it can be described by the difference between the verbs "suorittaa (=to carry out; to do)" and "suoriutua (=to get through, to pass)". Translating these two verbs is not easy, but the phenomenon is common worldwide: people try, for example, to "get through" the driving test to obtain a licence, although their main purpose should be to learn to drive a car safely. The same phenomenon is common in schools and universities. Pupils and students just try to "get through" the courses they find 'boring' or otherwise frustrating.

Society is based on achievements, giving good reason to use achievement motivation theories in motivation research (cf. McClelland 1961; Schiefele & al. 1979; Vepsäläinen 1980; Hakkarainen 1985; Heckhausen 1986).

Steinbock (1982) gives the theoretical background to this increasingly-common phenomenon. People become alienated from the goals that have been set for them. With reference to Adorno (1950) and Marcuse (1964) it can be argued that, in more authoritative societies and schools, people are ambitious to perform well at the tasks ("suorittaa leiviskänsä") set by teachers or employers, although they are alienated from the meaningfulness of their efforts. In a more narcissistic post-industrial society, people do not care whether their work is properly done - their main motivation is to "get through" (suoriutua) the tasks by expending the smallest effort (Steinbock 1982). This alienation is also one of the main problems of the formal educational system:

passing examinations - rather than learning - seems to be the main purpose of study.

The trend of the late 1980s in motivation training and consulting at school and in working life concentrated very much on external rewards. The situation bore a striking resemblance to Weiner's description of motivation research and its ideal goal, three decades ago: "However, for educational psychologists, the prime issue must be how to motivate people to engage in new learning, not how to get people to use what they already know, which is a more appropriate issue for industrial psychologists (Weiner 1990, 618). In the field of motivation research, intrinsic motivation is becoming the key issue (see 3.4.). This can be seen as a positive trend, and the pendulum of motivation research has swung towards educational goals.

This study has clearly shown the negative effects of instrumental motivation treatment. The results support the theory that instrumental motivation leads to surface learning strategy (Engeström 1984). Although this quasi-experiment was conducted in an informal learning setting - a science centre - the results have implications for any learning. Further research, even the repetition of this study in a formal setting, is a recommendation or a challenge to formal education.

Informal education is often regarded as the opposite of formal education. It has also been used as a tool to criticise school systems. Even the titles of informal-learning studies often describe their role as the opposites and alternatives to formal education: e.g. Deschooling

Society (Illich 1971a), and The Unschooled Mind (Gardner 1991). This also shows that the whole learning process is defined in terms of formal education (Falk & Dierking 1992). The next step in the study of informal learning might be the definition of learning per se, beyond the boundaries of formal education.

Science centres perform their own informal educational role in modern society. They are no longer isolated hands-on workshops created by a couple of science freaks, but have become part of a larger movement promoting public understanding of science: they are influenced by, and in turn affect the thinking of, not only the scientific community, but also other groups of society (Quin 1991; Persson 1992; Falk & Dierking 1992).

Elkind (1986) has criticised the methods used in early childhood education. Risks are involved in the institutionalisation of early childhood education. When educational programmes devised for school-age children are applied to pre-school children, self-directed learning for example is easily inhibited.

The same disturbing effect can be observed in informal learning. Schooling methods are all too easily transferred to informal education settings. This can be seen, for example, in the school programmes devised by many zoos, museums and science centres. Out-of-school programmes can play a useful educational role, but the characteristic features of the informal setting must be preserved in order to maintain and develop its value as an alternative learning medium.

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Intrinsic motivation test (translated from the Finnish)

For each statement, pupils were asked to check one of five options:

1 = agree strongly
2 = agree
3 = agree a bit
4 = disagree
5 = disagree strongly

	1	2	3	4	5
1. Learning gives me pleasure.					
2. We ought to be grateful that we are able to go to school.					
3. I do tasks - even difficult ones - eagerly when I know they are useful for my studies.					
4. I want to learn a lot about different things.					
5. I'm ready to work to make the lessons more interesting.					
6. I often have a bad conscience about not using my opportunity of studying at schoolbelter.					
7. It is important that we, the whole class, work together so that even the weakest pupils keep up with the others.					

Intrinsic motivation test (the original version in the Finnish)

pitää erittäin hyvin paikkansa = 1
pitää melko hyvin paikkansa = 2
pitää jonkin verran paikkansa = 3
pitää melko vähän paikkansa = 4
ei pidä lainkaan paikkansa = 5

1 2 3 4 5

1. Oppiminen tuottaa minulle iloa.

2. Meidän tulisi olla kiitollisia siitä, että saamme käydä koulua.

3. Ryhdyn innolla vaikeisiinkin tehtäviin kokiessani ne mielekkäiksi oman oppimiseni kannalta.

4. Haluan oppia tietämään paljon erilaisista asioista.

5. Olen valmis työskentelemään sen puolesta, että oppitunnit muodostuvat innostaviksi.

6. Minulla on usein huono omatunto, etten käytä paremmin hyväkseni mahdollisuutta opiskella koulussa.

7. Olisi tärkeätä, että voisimme koko luokka työskennellä yhdessä sen puolesta, että heikommatkin oppilaat pysyisivät mukana opetuksessa.

Instrumental motivation test (translated from the Finnish)

All the items had five alternatives:

1 = agree strongly
2 = agree
3 = agree a bit
4 = disagree
5 = disagree strongly

	1	2	3	4	5
1. I want to show the others that even I am good at something.					
2. The best reward for my achievements is my parent's joy.					
3. At school, I always try to get good grades.					
4. I behave myself at school because I'm afraid of being punished.					
5. When I fail, I easily get depressed and think that I'm no good for anything.					
6. I would work hard at school, if I was better rewarded for my achievement.					
7. I think it important that my teachers appreciate me and the work I do.					
8. I'm often afraid of failing in my school work.					
9. I try to work hard at school, because my parents expect me to do well.					
10. I try to do my home work with the least effort and as quickly as possible.					
11. I go to school because I have to.					
12. I believe I can reach the goals I have set myself.					

Instrumental motivation test (the original version in the Finnish)

pitää erittäin hyvin paikkansa = 1
pitää melko hyvin paikkansa = 2
pitää jonkin verran paikkansa = 3
pitää melko vähän paikkansa = 4
ei pidä lainkaan paikkansa = 5

	1	2	3	4	5
1. Haluan näyttää muille, että kyllä minäkin jossain pärjään.					
2. Vanhempieni ilo on paras palkka suorituksistani.					
3. Pyrin koulussa jatkuvasti parempiin saavutuksiin.					
4. Käyttäydyn koulussa kunnolla, koska pelkään saavani rangaistuksia.					
5. Masennun helposti epäonnistumisistani ja ajattelen ettei minusta ole mihinkään.					
6. Työskentelisin koulussa ahkerasti, jos minua palkittaisiin paremmin suorituksistani.					
7. Minusta olisi erittäin tärketä, että opettajat arvostaisivat minua ja työtäni.					
8. Pelkään usein epäonnistuvani koulusuorituksissani.					
9. Yritän työskennellä koulussa ahkerasti, koska vanhempani odottavat minulta hyviä suorituksia.					
10. Pyrin selviytymään koulutehtävistäni mahdollisimman vähällä vaivalla ja nopeasti.					
11. Käyn koulua pääasiassa siksi, että on pakko.					
12. Uskon, että voin saavuttaa itselleni asettamani tavoitteet.					

Situation motivation test (translated from the Finnish)

1. I think the exhibition was

__ very enjoyable
__ quite enjoyable
__ o.k.
__ quite boring
__ very boring

2. I learned new things in the exhibition

__ very many
__ quite a lot
__ no opinion
__ not many
__ very few

3. The own-time period in the exhibiton was

__ much too long
__ rather too long
__ just right
__ rather too short
__ much too short

4. The guide in the exhibition told us the folowing about sleep

"People sleep for about a third of their life-time. Sleeping is considered important for refreshing the body. Many sleep researchers are on the opinion that sleep is especially important for the functioning of the brain. Children need more sleep than adults. The amount of sleep adults need varies from one person to another. REM-sleep is part of dreaming."

What else would you like to know about sleep?
Write 2-4 questions for the guide!_____
_____
_____
_____

5. Visiting the exhibition can improve my school grades.

__ very much
__ quite a lot
__ no opinion
__ a bit
__ very little

6. The way the guide told us about the exhibition was

__ too difficult
__ quite difficult
__ just right
__ a bit too simple
__ far too simple

Situation motivation test (the original version in the Finnish)

1. Näyttely oli mielestäni

___ erittäin hauska
___ melko hauska
___ samantekevä
___ melko ikävystyttävä
___ erittäin ikävystyttävä

2. Opin näyttelyssä uusia asioita

___ erittäin paljon
___ melko paljon
___ en osaa sanoa
___ aika vähän
___ erittäin vähän

3. Näytelyssä omatoimisesti vietetty aika oli

___ aivan liian pitkä
___ hieman liian pitkä
___ sopiva
___ hieman liian lyhyt
___ aivan liian lyhyt

4. Opas kertoi näyttelyssä nukkumisesta mm. seuraavaa:

"Ihminen nukkuu noin kolmasosan elämästään. Nukkumista on pidetty tärkeänä elimistön elpymiselle. Monet unitutkijat ovat sitä mieltä, että uni on tarpeen nimenomaan aivojen toiminnalle. Lapset tarvitsevat enemmän unta kuin aikuiset. Aikuisilla unen tarve on yksilöllistä. REM-uni liittyy unien näkemiseen."

Mitä muuta haluasit tietää nukkumisesta?
Tee oppaalle 2-4 kysymystä! _____
_____
_____
_____

5. Näyttely voi hyödyttää koulunumeroitani

___ erittäin paljon
___ melko paljon
___ en osaa sanoa
___ melko vähän
___ erittäin vähän

6. Opas kertoi asioista

___ aivan liian monimutkaisesti
___ hieman liian monimutkaisesti
___ sopivasti
___ hieman liian yksinkertaisesti
___ aivan liian yksinkertaisesti

Knowledge test (translated from the Finnish)

1. The number of bones in a human skeleton is

a) 76 b) 96 c) 127 d) 196 e) 206

2. The number of muscles a human has is

a) about 500
b) about 400
c) about 300
d) about 200
e) about 100

3. Write the names of the auditory bones.

_____
_____
_____

4. What are the main functions of our bones?

_____
_____

5. An human adult contains about ___ litres of blood.

6. While resting, a human heart pumps blood at a rate of about

a) 3 litres per minute
b) 5 litres per minute
c) 7 litres per minute
d) 9 litres per minute
e) 11 litres per minute

7. The heart of a top athlete in hard training can pump blood at a rate of

a) 40 litres per minute
b) 30 litres per minute
c) 20 litres per minute
d) 10 litres per minute
e) 5 litres per minute

8. How does the muscle action of the heart and diaphragm differ from that of the biceps muscle?

_____
_____
_____
_____

9. A new born baby sleeps about

a) 20 hours
b) 18 hours
c) 16 hours
d) 14 hours
e) 12 hours

10. REM-sleep is

a) sleep caused by sleeping pills
b) Relaxing Efficient Memory -sleep
c) sleep typical older people
d) eye movements and dreaming while sleeping
e) a dog's sleep

11. Why do people being need to sleep?

_____
_____
_____
_____

12. What is the name of the traditional Finnish treatment that uses similar principles to acupuncture?_____
_____

13. Describe, in your own words, what the term "national disease" means: _____
_____
_____
_____

14. What is the most common "national disease" in Finland?
_____

15. In the exhibition the principle of the "Unbalanced room" was described? How is this phenomenon produced?

_____
_____
_____
_____

16. The main artery out of the heart is called _____.

17. True or false?

After exercise, the liver changes, lactic acid into glucose or sugar.	T	F
Continnous exercise (like jogging) effects the lungs more than the heart.	T	F
The hardest substance in a human body is tartar.	T	F
If you run, you use more energy than if you walked the same distance.	T	F

18. The functions of blood circulation in man.
(space for answer)

Knowledge test (the original version in the Finnish)

1. Ihmisessä on luita

a) 76 kpl b) 96 kpl c) 127 kpl d) 196 kpl e) 206 kpl

2. Ihmisellä on lihaksia

a) noin 500 kpl
b) noin 400 kpl
c) noin 300 kpl
d) noin 200 kpl
e) noin 100 kpl

3. Nimeä ihmisen kuuloluut: _____
_____

4. Mitkä ovat ihmisen luuston päätehtävät? _____
_____

5. Aikuisessa ihmisessä on yhteensä noin ____ litraa verta.

6. Lepotilassa ihmisen sydän pumppaa verta noin

a) 3 litraa minuutissa
b) 5 litraa minuutissa
c) 7 litraa minuutissa
d) 9 litraa minuutissa
e) 11 litraa minuutissa

7. Huippu-urheilijan sydän voi pumpata kovassa rasituksessa verta

a) 40 litraa minuutissa
b) 30 litraa minuutissa
c) 20 litraa minuutissa
d) 10 litraa minuutissa
e) 5 litraa minuutissa

8. Miten sydänlihaksen ja pallealihaksen toiminta eroaa hauislihaksen toiminnasta?

_____
_____
_____
_____
_____

9. Vastasyntynyt lapsi nukkuu noin

a) 20 tuntia vuorokaudessa
b) 18 tuntia vuorokaudessa
c) 16 tuntia vuorokaudessa
d) 14 tuntia vuorokaudessa
e) 12 tuntia vuorokaudessa

10. REM-uni tarkoittaa

a) unilääkkeillä aiheutettua unta
b) Rentouttavaa Elimistön Muisti -unta
c) vanhoille ihmisille tyypillistä unta
d) silmänliikkeitä ja unen näkemistä nukkuessa
e) koiranunta

11. Minkä takia ihminen tarvitsee unta?

12. Mikä on nimeltään se perinteinen suomalainen kansanlääketieteen hoitomuoto, jonka periaatteet vastaavat osittain akupuntuurihoitoa?

13. Selitä omin sanoin, mitä tarkoittaa "kansantauti":

14. Mikä on suomalaisten yleisin kansantauti? _____

15. Näyttelyssä esiteltiin Linnanmäellä oleva "Vino huone", jossa ihmiset alkavat horjua ja saattavat jopa kaatua. Mistä tämä ilmiö johtuu?

16. Sydämestä lähtevä päävaltimo on nimeltään _____.

17. Ovatko seuraavat väittämät oikein (O) vai Väärin (V). Rengasta oikea vaihtoehto.

Maksa muuttaa rasituksen jälkeen maitohapon glykogeeniksi eli sokeriksi.	O	V
Kestävyysliikunta vaikuttaa enemmän keuhkojen kuin sydämen toimintaan.	O	V
Ihmisen kovin ainesosa on hammaskivi.	O	V
Jos ihminen juoksee tietyn matkan, hän kuluttaa enemmän energiaa kuin kävellessään tämän matkan.	O	V

18. Ihmisen verenkierron tehtävät. (tilaa paperilla)

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ISBN 951-45-6475-8
ISSN 0359-4203
Helsinki 1993
Yliopistopaino